Selection of projects for damage mitigation using a valuation approach

Douglas M. Henderson

Disaster Management, Inc.
Port St. Lucie, FL 34952-6011, USA
E-mail: doug@disastermgt.com

Abstract: A major university located in a region of high-hurricane activity aspired to complete hurricane damage mitigation projects. After potential hurricane damage mitigation projects had been identified, a logical method to prioritise the projects needed to be developed to maximise the use of available financial resources. We developed and implemented a valuation approach to determine the value of mitigation projects. This paper examines the analysis and expands the analysis to evaluate the relationship between the present value of the project cost and mitigation project.

Keywords: business continuity; project valuation; mitigation.

Reference to this paper should be made as follows: Henderson, D.M. (2010) 'Selection of projects for damage mitigation using a valuation approach', *Int. J. Business Continuity and Risk Management*, Vol. 1, No. 2, pp.197–210.

Biographical notes: Douglas M. Henderson is the President of Disaster Management Inc. He has 20 years of experience with major consulting firms. His clients include Bombardier Capital Group, CP Ships, Discovery Channel, Florida International University, NATLSCO, PGA, University of Miami, United Educators Insurance Company and Virginia Commonwealth University. He has a Mathematics degree from the University of Arizona. He is an FSA – Fellow, Society of Actuaries and CBCP – Certified Business Continuity Professional. He is the author of *Is Your Business Ready for the Next Disaster?*, the *Comprehensive Business Continuity Management Program*, the *Continuity of Operations Plan for Colleges & Universities* and the *Hurricane and Flood Plan*.

1 Introduction

Business Continuity Management has multiple purposes. Ideally, a good Business Continuity Management programme should prevent a disaster where possible. For a disaster that cannot be prevented, Business Continuity Management is designed to minimise the interruption of business operations, mitigate damages, maintain customer service standards, maintain quality controls, safeguard the reputation and brand, reduce legal exposures, comply with relevant laws, act in accordance with industry best practices and provide for the safety and security of employees and visitors. Clearly, an important purpose of Business Continuity Management is to identify projects that will accomplish these objectives by mitigating (reducing or eliminating) damages.

A major university located in a region of high-hurricane activity is aspired to complete hurricane damage mitigation projects to protect lives and reduce campus damage. The initial phase of the analysis was to identify potential hurricane damage mitigation projects. After the potential hurricane damage mitigation projects had been identified and significant financial resources were secured, a logical method to prioritise the projects needed to be developed. In this manner, the university could maximise the use of available internal financial resources and grants designated for hurricane damage mitigation.

These calculations can be expanded to develop a general algorithm to evaluate the relationship between the present value of the project cost and mitigation project. The present value of the project cost includes the initial and annual maintenance cost associated with the mitigation project under examination. The present value of the mitigation project is the financial measurement of the ability of the mitigation project to reduce damage (physical damage, personal injuries, loss of asset use, etc.) for any specific hazard or for multiple hazards.

1.1 Other approaches

In July 2006, the University of Mississippi released a report that addresses the natural hazards facing the university. The report includes a detailed risk assessment, an analysis of vulnerabilities to the campus and a mitigation strategy. The analysis does estimate expected financial losses by hazard. The financial losses are largely based on asset damages to both buildings and building content.

In July 2006, the University of Colorado released a report that addresses the natural hazards facing the university. The report includes a detailed risk assessment, an analysis of vulnerabilities to the campus and a mitigation strategy. The risk assessment is particularly impressive. The analysis does estimate expected financial losses by hazard. The financial losses are largely based on asset damages to both buildings and building content.

In August 2003, Federal Emergency Management Agency (FEMA) released a report/handbook that defines how higher education institutions can develop disaster resistant universities with damage mitigation projects. Page 32 of the report presents guidelines for prioritising damage mitigation projects. Worksheets are subsequently presented for estimating financial losses based on the following three factors:

1 damage to building structure
2 damage to building contents
3 losses resulting from the loss of use of the building.

1.2 Damage mitigation projects

The project started with the university selecting the buildings that were to be considered for hurricane damage mitigation. Campus buildings that were scheduled to be replaced over the next ten years were eliminated from the analysis. The university also eliminated several buildings that were of very low value.

Overall, there were approximately 60 campus buildings under consideration. The university then engaged an Engineering Consulting Company and a Business

Continuity Consulting Company. This paper focuses on the role of the Business Continuity Consultants.

The Engineering Consultants identified approximately 150 hurricane damage mitigation projects for the university. Most projects were for hurricane wind protection (shutters, hurricane 'proof' glass, etc.) but other projects included roof improvements (repair, upgrade, strapping, etc.), building structural reinforcements (bracing) and a few flood-related projects (check valves, sump pump systems, levees, etc.).

The Engineering Consultants then identified the project cost associated with the completion of each hurricane damage mitigation project. In addition to identifying project cost, the Engineering Consultants classified the 'Project Effectiveness' of each project as 'high, medium or low'. The 'Project Effectiveness' is essentially a measurement of the ability of the project to mitigate damage.

The Business Continuity Consultants identified additional business and financial factors associated with each campus building where a proposed damage mitigation project was identified. The Business Continuity Consultants considered the value of the Building Contents at risk, the value of the building use and the difficulty in replacing the building. A life safety factor to evaluate the risk to faculty, staff, students and others was also introduced. The Business Continuity Consultants then developed a simple mathematical algorithm to prioritise the damage mitigation projects.

For the purpose of this paper, hurricane damage mitigation projects for the following general building types are analysed:

- Academic/Classroom.
- Administrative Office.
- Art Museum.
- Main Library.
- Medical Centre.
- Research Lab.
- Residence Hall.
- Utility Building.

2 Factors and variables to be considered

2.1 Factors

To fully determine the value of each hurricane damage mitigation project, the following factors were used:

- Project Cost.
- Project Effectiveness.
- Building Contents.
- Building Functions.

- Building Replacement.
- Life Safety.

Some of the factors can be assigned a dollar value and can be easily prioritised. Other factors do not readily convert into a dollar value. After considerable deliberation, attempting to use dollar values to prioritise each factor was abandoned in favour of a relative value weighting. Every factor under analysis was assigned a value ranging from one to ten using dollar values where appropriate and other measurable statistics and/or judgement as necessary.

2.2 Project Cost

Converting the Project Cost for each project under analysis to a scale of one to ten was probably the simplest part of the entire project. Note that the Project Cost is inversely proportional to the value of the hurricane damage mitigation project (the project with the highest Project Cost is of the lowest value and the project with the lowest Project Cost is of the highest value). Thus, the project with the highest Project Cost was assigned a value of one and the project with the lowest Project Cost was assigned a value of ten. All other projects were assigned a value between one and ten based on linear interpolation.

On a scale of one to ten, the following values for Project Cost were assigned:

- highest Project Cost = 1
- lowest Project Cost = 10

2.3 Project Effectiveness

Project Effectiveness was a semi-mathematical determination made by the Engineering Consultants. A project was assigned a ‘high’ level of Project Effectiveness if it provided complete protection from a category 5 hurricane. Many (if not most) hurricane shutter projects fall into this category. Good hurricane shutters should offer complete protection against a category 5 hurricane to windows and doors. However, some buildings do not have roofs that can withstand (or can be retrofitted to withstand) category 5 hurricane winds and thus complete protection against a category 5 hurricane is impossible. The same analysis can be made for buildings that might experience flooding.

Projects were assigned a ‘low’ level of Project Effectiveness if it provided only partial protection from hurricane force winds and/or torrential hurricane rain with subsequent flooding. Projects were assigned a ‘medium’ level of Project Effectiveness if it provided good but less than complete protection from hurricane force winds and/or torrential hurricane rain with subsequent flooding.

On a scale of one to ten, the following values for Project Effectiveness were assigned:

- Project Effectiveness High = 8
- Project Effectiveness Medium = 5
- Project Effectiveness Low = 2

2.4 Building Contents

One of the easiest components to determine and prioritise is the insured value of the Building Contents. Insured values were readily obtainable and the building with the highest insured value of Building Contents was assigned a value of ten and the building with the lowest absolute dollar Building Contents was assigned a value of one. All other projects were assigned a value between one and ten based on linear interpolation. On the surface, this appears to complete the information needed to prioritise Building Contents. However, a couple of additional factors were considered.

A problem immediately arose as the insured value of Building Contents in the Art Museum and the Main Library greatly exceeded the corresponding insured value for all other buildings – including the university's extensive Medical Centre. A limit of $25,000,000 was placed as a maximum value for all Building Contents.

There are certain assets where the exact value was difficult to determine. For example, artworks and library books are difficult to value. There was also consideration given to assets that are very difficult or impossible to replace. Certain artworks, museum pieces and library books fall into this category. Also falling into this category are many research assets – what is the value of a moon rock, a collection of writings donated 100 years ago or an ice core from a 1952 artic expedition?

A building with a value of Building Contents equal to or greater than $25,000,000 was assigned a value of ten and the building with the lowest value of Building Contents was assigned a value of one. All other buildings were assigned a value between one and ten based on linear interpolation. Adjustments were then made to account for the other factors noted.

On a scale of one to ten, typical values for Building Contents were as follows:

- Academic/Classroom = 2
- Administrative Office = 2
- Art Museum = 10
- Main Library = 10
- Medical Centre = 10
- Research Lab = 8
- Residence Hall = 4
- Utility Building = 8[1]

2.5 Building Functions

The analysis started by equating the value of Building Functions to the revenue generated by the building. Although the revenue generated by the building is a factor, the actual contribution by the building to the post-disaster recovery efforts was considered to be a most critical factor. Moreover, many campus buildings do not directly produce any revenue.

The Medical Centre was considered to be the building with the most value in a post-disaster environment and it also was the building that produced the most revenue. Although not immediately obvious, many Utility Buildings are critical to overall university operations. Few normal university operations can be conducted without basic utility services and campus damage repair is seriously degraded without basic utility services and maintenance buildings.

Based on their overall contribution to this particular university, buildings with Research Laboratories were assigned a higher priority than Academic/Classroom buildings. Based on revenue generation, Residence Halls were assigned a value greater than the value assigned to Academic/Classroom and Administrative Office buildings.

On a scale of one to ten, typical values for Building Functions were as follows:

- Academic/Classroom = 2
- Administrative Office = 2
- Art Museum = 2
- Main Library = 2
- Medical Centre = 10
- Research Lab = 6
- Residence Hall = 4
- Utility Building = 8

2.6 Building Replacement

The analysis to determine the Building Replacement factor was based on the assumption that the more difficult a building is to replace, the more important it is to mitigate damages to the building. A very large number of campus buildings can be fairly easily replaced (at least temporarily) with modular units and temporary structures after a disaster. For this particular university, there are adequate available parking areas, athletic fields and open spaces to support these structures.[2]

On a scale of one to ten, typical values for Building Replacement were as follows:

- Academic/Classroom = 2
- Administrative Office = 2
- Art Museum = 6
- Main Library = 4
- Medical Centre = 10
- Research Lab = 8
- Residence Hall = 4
- Utility Building = 8

2.7 Building Factors

The business and financial factors associated with each campus building can be summarised as follows:

Building Type	*Building Contents*	*Building Functions*	*Building Replacement*
Academic/Classroom	2	2	2
Administrative Office	2	2	2
Art Museum	10	2	6
Main Library	10	2	4
Medical Centre	10	10	10
Research Lab	8	6	8
Residence Hall	4	4	4
Utility Building	8	8	8

2.8 Life Safety

The analysis to determine the Life Safety factor was most challenging. Certainly, the dollar value of a human life is difficult to determine and, in the end, no attempt was made to determine the dollar value of a human life.

Arguments can be made that the Life Safety factor trumps all other factors as it is just about the only thing that cannot be replaced. Arguments can also be made that Life Safety should not be a consideration at all – if any campus building is not completely safe from hurricane force wind and/or flooding, then simply evacuate the building or the entire campus if necessary. Clearly evacuating a Residence Hall is an inconvenience, evacuating the Medical Centre is extremely difficult and evacuating the entire campus is both difficult and expensive.

In the final analysis, it was determined to evaluate the algorithm twice, placing an extremely heavy weight on Life Safety (ten) for one evaluation (in buildings where students, employees and others would be sheltered during a storm) and completely ignoring the Life Safety factor for the other evaluation. In this way, university management was given the opportunity to consider the Life Safety factor either way.

3 Project valuation algorithm

The factors included in the algorithm were as follows:

- Project Cost = PC.
- Project Effectiveness = PE.
- Building Contents = BC.
- Building Functions = BF.
- Building Replacement = BR.
- Life Safety = LS.

Note that there was no consideration of the Building Structure in the analysis. This was due to the fact that all the selected campus buildings would all structurally survive a hurricane. Had this not been the case or if the analysis was for an earthquake, a Building Structure factor would have been included.

The following relative values (expressed as percentages) for each factor had to be determined:

- Project Cost = PC%
- Project Effectiveness = PE%
- Building Contents = BC%
- Building Functions = BF%
- Building Replacement = BR%
- Life Safety = LS%

$$PC\% + PE\% + BC\% + BF\% + BR\% + LS\% = 100\%$$

A simple linear equation utilising each factor with variable weighting to determine the Mitigation Project Relative Value (MPRV) algorithm was defined as follows:

$$\begin{aligned} MPRV = {} & PC \times PC\% + PE \times PE\% + BC \times BC\% + BF \times BF\% \\ & + BR \times BR\% + LS \times LS\% \end{aligned}$$

It was recognised that some of the factors are more important than other factors. Moreover, the importance of each factor is somewhat subjective and different users of the study would place different emphasis on the various factors. Admittedly, the initial assigning of the relative values was largely subjective.

When analysing the results without the Life Safety factor, relative values were assigned as follows:

- Project Cost (PC% = 15%)
- Project Effectiveness (PE% = 25%)
- Building Contents (BC% = 20%)
- Building Functions (BF% = 20%)
- Building Replacement (BR% = 20%)
- Life Safety (LS% = 0%)

$$MPRV = PC \times 15\% + PE \times 25\% + BC \times 20\% + BF \times 20\% + BR \times 20\%$$

When analysing the results with the Life Safety factor,[3] relative values were assigned as follows:

- Project Cost (PC% = 7.5%)
- Project Effectiveness (PE% = 12.5%)
- Building Contents (BC% = 10%)
- Building Functions (BF% = 10%)
- Building Replacement (BR% = 10%)
- Life Safety (LS% = 50%)

$$MPRV = PC \times 7.5\% + PE \times 12.5\% + BC \times 10\% + BF \times 10\% + BR \times 10\% + LS \times 50\%$$

4 Calculating the results

Basically, the algorithm was initially evaluated for each building both with and without the Life Safety factor. The analysis was then made for each damage mitigation project under consideration.

4.1 Building Evaluation

Three of the factors (Building Contents, Building Functions and Building Replacement) are all building-specific. These factors account for 60% of the algorithm relative value when the Life Safety factor is not considered and 30% of the algorithm relative value when the Life Safety factor is considered. The MPRV algorithm by building-type without the Life Safety factor was as follows:

$$\text{General MPRV} = \text{PC} \times 15\% + \text{PE} \times 25\% + \text{BC} \times 20\% + \text{BF} \times 20\% + \text{BR} \times 20\%$$

Academic/Classroom MPRV = PC × 15% + PE × 25% + 1.2

Administrative Office MPRV = PC × 15% + PE × 25% + 1.2

Art Museum MPRV = PC × 15% + PE × 25% + 3.6

Main Library MPRV = PC × 15% + PE × 25% + 3.2

Medical Centre MPRV = PC × 15% + PE × 25% + 6.0

Research Lab MPRV = PC × 15% + PE × 25% + 4.4

Residence Hall MPRV = PC × 15% + PE × 25% + 2.4

Utility Building MPRV = PC × 15% + PE × 25% + 4.8

Independent of the actual hurricane damage mitigation project under consideration (removing the Project Cost and the Project Effectiveness factors), the MPRV by building-type was as follows:

Medical Centre MPRV = 6.0

Utility Building MPRV = 4.8

Research Lab MPRV = 4.4

Art Museum MPRV = 3.6

Main Library MPRV = 3.2

Residence Hall MPRV = 2.4

Academic/Classroom MPRV = 1.2

Administrative Office MPRV = 1.2

When considering the Life Safety factor, the university wanted to shelter students in Resident Halls and did not want to evacuate the Medical Centre. It would also be advantageous to shelter a small contingency of employees at a few Utility Buildings – the main Physical Plant, the Police Station and the Communication Centre (where the primary Emergency Operations Centre is located).

The MPRV algorithm by building-type with the Life Safety factor included was as follows:

$$\text{MPRV}_{\text{LS}} = \text{PC} \times 7.5\% + \text{PE} \times 12.5\% + \text{BC} \times 10\% + \text{BF} \times 10\% + \text{BR} \times 10\% + \text{LS} \times 50\%$$

Academic/Classroom MPRV_{LS} = PC × 7.5% + PE × 12.5% + .6 + 0.0

Administrative Office MPRV_{LS} = PC × 7.5% + PE × 12.5% + .6 + 0.0

Art Museum MPRV_{LS} = PC × 7.5% + PE × 12.5% + 1.8 + 0.0

Main Library MPRV_{LS} = PC × 7.5% + PE × 12.5% + 1.6 + 0.0

Medical Centre MPRV_{LS} = PC × 7.5% + PE × 12.5% + 3.0 + 5.0

Research Lab MPRV_{LS} = PC × 7.5% + PE × 12.5% + 2.2 + 0.0

Residence Hall MPRV_{LS} = PC × 7.5% + PE × 12.5% + 1.2 + 5.0

Utility Building (without shelter) MPRV_{LS} = PC × 7.5% + PE × 12.5% + 2.4 + 0.0

Utility Building (with shelter) MPRV_{LS} = PC × 7.5% + PE × 12.5% + 2.4 + 5.0

Independent of the actual hurricane damage mitigation project under consideration (removing the Project Cost and the Project Effectiveness factors), the MPRV with the Life Safety Factor by building-type was as follows:

Medical Centre MPRV_{LS} = 8.0

Utility Building (with shelter) MPRV_{LS} = 7.4

Residence Halls MPRV_{LS} = 6.2

Utility Building (without shelter) MPRV_{LS} = 2.4

Research Lab MPRV_{LS} = 2.2

Art Museum MPRV_{LS} = 1.8

Main Library MPRV_{LS} = 1.6

Academic/Classroom MPRV_{LS} = .6

Administrative Office MPV_{LS} = .6

5 Mathematical models and limitations

5.1 Current mathematical model

The current model has two general variables – 'factors' which are expressed on a scale of one to ten and a 'relative value' (weight) assigned to each factor expressed as a percent. Expressed mathematically, where X = factor and Y = relative value, we have the following:

Mitigation Project Relative Value = MPRV

$$\text{MPRV} = \sum (X_{\text{pc}})(Y_{\text{pc}}) + (X_{\text{pe}})(Y_{\text{pe}}) + (X_{\text{bc}})(Y_{\text{bc}}) + (X_{\text{bf}})(Y_{\text{bf}}) + (X_{\text{br}})(Y_{\text{br}}) + (X_{\text{ls}})(Y_{\text{ls}})$$

5.2 Expanded mathematical model

Our model contemplated only hurricanes and a more expanded model would include multiple hazards. An expanded model will include a third variable – a hazard-specific risk component. The hazard-specific risk component is determined by two variables – a probability of the hazard occurring and the impact or consequence of the hazard.

In general, each factor is independent of the probability (*P*) of the event occurring[4] – if hazard (*h*) occurs, each factor is exposed equally. However, the impact (*I*) of each hazard (*h*) may be different for each factor. For example, a blizzard will not likely damage the Building Structure or Building Contents of a modern well-constructed building but may impact Building Functions (at least temporarily) and present some level of Life Safety risk. A powerful earthquake or tornado will likely impact all factors at a high level. Finally, the number of factors can be increased from six to as many as desired (*m*). The expanded MPRV now can be expressed as follows:

$$\text{MPRV} = \sum P_h \left(\sum (X_{m1})(Y_{m1})(I_{m1h}) + (X_{m2})(Y_{m2})(I_{m2h}) + (X_{m3})(Y_{m3})(I_{m3h}) + \cdots \right)$$

Impact can be expressed in terms of a percentage that can range from 0% to 100%. Probability is expressed as a percentage equal to the best estimate of the actual probability of the hazard ever occurring.

5.3 Limitations

Probably, the single greatest limitation is obtaining or developing accurate data. Much of the data determination was subjective or based on only semi-mathematical calculations. Clearly, the accuracy of the overall results cannot be greater than the accuracy of the data.

When actual decisions are made in determining which hurricane damage mitigation projects will be authorised, additional factors enter into the equation. When executive management makes the final decisions, the calculated MPRVs are used as a guideline. Authority within the organisation, preferred projects, preferred buildings, etc. will subjectively influence the results. These additional factors are largely unknown to the consulting team working on the project and can actually trump all other considerations.

Many of the factor values are determined by interpolation, linear interpolation to be specific. A more sophisticated algorithm for making interpolations obviously could be considered. The MPRV algorithm is relatively simple. More sophisticated algorithms would yield more precise results but probably would not greatly increase the overall accuracy of the results. In summary, given the accuracy of the data and the subjective nature of the decision-making process, a more sophisticated algorithm using computer modelling would add little value to the final results and would greatly increase the actual cost of the analysis.

5.4 Cost-justifying the damage mitigation project

The greatest limitation is that the calculations do not determine if the damage mitigation project is cost-justified. The calculations must determine that the Mitigation Project Cost (MPC) will be less than the Mitigation Project Value (MPV). To determine MPC and

MPV, each of the factors (X_m) will need to be expressed in terms of dollars and the algorithm will need to be adjusted.

The MPV algorithm does not include the Project Cost. The Project Cost factor is the MPC. The Project Effectiveness factor also needs special treatment. Project Effectiveness cannot be expressed in terms of dollars; however, the Project Effectiveness can be expressed as a percentage that can range from 0% to 100%. Project Effectiveness less than 100% reduces the value of the MPV algorithm.

Although presented as a single value in the analysis, Project Effectiveness (PE) can also vary among the various MPV factors. For example, a damage mitigation project designed to protect building assets (building furniture, equipment, etc.) should improve the Building Content risk but may do nothing to improve the Building Structure risk. The expanded MPV model now becomes:

$$\text{MPV} = \sum_h (X_{m1})(Y_{m1})(I_{m1h})(P_{m1h})(\text{PE}_{m1h}) + (X_{m2})(Y_{m2})(I_{m2h})(P_{m2h})(\text{PE}_{m2h}) + (X_{m3})(Y_{m3})(I_{m3h})(P_{m3h})(\text{PE}_{m3h}) + \cdots$$

In addition and most importantly, the MPV and MPC will now need to be expressed in terms of a Present Value – PV(MPV) and PV(MPC), respectively. The Present Value calculations will require the introduction of a reasonable interest rate (i) that will establish an annual rate of discount (v) where $v = 1/(1 + i)$.

A rate of inflation (k) can also be incorporated into the present value calculations. This can be most easily accomplished by defining a net rate of interest (j) where:

$$\frac{1}{1+j} = \frac{1+k}{1+i}$$

$$1+j = \frac{1+i}{1+k}$$

$$j = \frac{1+i}{1+k} - 1$$

$$j = \frac{(1+i)-(1+k)}{1+k}$$

$$j = \frac{i-k}{1+k}$$

The useful value of any building and damage mitigation project will not be infinite. Thus, the number of years to be included in the PV(MPV) calculation will be set equal to (n). Assuming that the probability of the hazard strike is midyear, the PV(MPV) can be expressed as follows:

$$\text{PV(MPV)} = \sum_h \Bigg(\sum_n (X_{m1})(Y_{m1})(I_{m1h})(P_{m1h})(PE_{m1h})v^{1/2} + (X_{m2})(Y_{m2})(I_{m2h})(P_{m2h})(PE_{m2h})v^{3/2} + (X_{m3})(Y_{m3})(I_{m3h})(P_{m3h})(PE_{m3h})v^{5/2} + \cdots + (X_{mn})(Y_{mn})(I_{mnh})(P_{mnh})(PE_{mnh})v^{n-1/2} \Bigg)$$

Impact (I) can still be expressed in terms of a percentage that can range from 0% to 100%. Probability (P) is now expressed as a percentage equal to the best estimate of the actual *annual* probability of the hazard occurrence (rather than the actual probability of the hazard *ever* occurring). The Project Effectiveness is expressed as a percentage. The factor (X) under consideration is expressed in terms of dollars. The relative value (Y) is expressed as a percent and will most likely be equal to 100% – with the factors being expressed in terms of dollars there is an automatic weighting already assigned.[5]

Although presented as a single value in the analysis, Project Cost (PC) can also be expressed in terms of an Initial Project Cost (IPC) and an annual maintenance or Ongoing Project Cost (OPC). The expanded PV(MPC) model now becomes:

$$\text{PV(MPC)} = \text{(IPC)} + \sum_n \text{(OPC)} \times v^{1/2} + \text{(OPC)} \times v^{3/2} + \text{(OPC)} \times v^{5/2} + \cdots + \text{(OPC)} \times v^{n-1/2}$$

The damage mitigation project is cost-justified if Present Value Mitigation Project Value PV(MPV) is greater than the Present Value Mitigation Project Cost PV(MPC).

6 Conclusion

Now the university was in a position to make a quantitative analysis of hurricane damage mitigation projects. Most importantly, the university was able to secure rather large grants for hurricane damage mitigation projects from federal, state and local levels. The university then proceeded to complete hurricane damage mitigation projects starting with the projects that were of the highest MPV.

In a broader scope, this type of analysis can be used to evaluate damage mitigation projects for other major hazards. Earthquakes, floods and tornadoes all can damage or destroy multiple buildings. When compared to hurricanes, the type of damages, types of damage mitigation projects, disaster warning periods (if any), etc. will be different. The factors used and the relative value of the factors may also be different. However, the algorithm and logic can be applied rather easily to other major hazards.

The MPRV algorithm can also be converted into a Present Value Mitigation Project Value PV(MPV) algorithm and a Present Value Mitigation Project Cost PV(MPC) algorithm to cost-justify a proposed damage mitigation project. Essentially, that is, how FEMA is cost-justifying damage mitigation projects using three factors.

The project also develops a logical method for evaluating the relative importance of each campus building. In a chaotic post-disaster environment where multiple buildings are damaged, having campus buildings prioritised in an order of importance is a useful tool in determining which buildings should be repaired or replaced first.

References

Federal Emergency Management Agency (FEMA) (2003) Available at: http://www.eeri.org/mitigation/files/FMEA443.disaster.resist.univ.pdf.

University of Colorado (2006) Available at: http://www.dola.state.co.us/dem/mitigation/university_boulder_plan.pdf.

University of Mississippi (2006) Available at: http://www.olemiss.edu/orgs/ccep/ApprovedDRUPlanAug7ver2.pdf.

Notes

[1] Some Utility Buildings were designated with lower values.

[2] For universities located in urban areas there may be inadequate open space to support modular units and temporary structures. In this environment, all buildings may be difficult to replace.

[3] In buildings where employees, students or others were to be sheltered during the storm.

[4] There could be some hazards that are building-specific. For example, fires may be more likely in certain buildings (buildings where students reside, research buildings with highly flammable chemical contents, etc.). If this additional level of detail is desired, the expanded MPRV now can be expressed as follows:

$$\text{MPRV} = \sum (X_{m1})(Y_{m1})(I_{m1h})(P_{m1h}) + (X_{m2})(Y_{m2})(I_{m2h})(P_{m2h}) + (X_{m3})(Y_{m3})(I_{m3h})(P_{m3h}) + \cdots$$

[5] There may be situations where the relative value may be less than 100%. For example, if building contents are obsolete and are scheduled for replacement in the near future, the relative value might be set as low as 0% for the building content factor. In fact, in a more general situation, different factors might have a different term of usefulness (building structure might be considered useful for 60 years but building content useful for 10 years). Assigning variable relative values could incorporate additional considerations.