Evidence-based, mission-oriented Corporate Real Estate Management.

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Abstract

The Dutch Government Real Estate Agency (RVB, Rijks Vastgoed Bedrijf) is one of the largest corporate real estate managers in The Netherlands being responsible for approximately 2000 government buildings and terrain of the Ministry of Defence ; from approximately 350 monuments to buildings of various types like palaces, museums, offices, penitentiary institutions, bunkers, shelters, airfields and harbours, in total some 12 million gross square meter floor space. The annual maintenance budget is in the order of some 200 million €. Daily maintenance is managed via 5-7 year service level agreements; investments and refurbishments are planned over a five year interval. Every five years the condition of building elements are established by a team of inspectors, using the Dutch NEN2767 condition assessment norm. A building advisor then has to integrate this information in a budget proposal in order to cost effectively maintain the overall real estate condition in line with the mission of the RVB.

To this end we developed a decision support tool (prototype in Excel) in which the RVB management experts link the building elements to one or more of the mission categories (safety, health, , energy, environment and quality, SHEEQ). The inspection results are registered under these headings and are weighted via the Analytical Hierarchy Process with respect to the RVB mission. The advisor, in this way, easily obtains a ranked list of potential refurbishment candidates. He / she then will allocate budget, first for obligatory, then for the most critical actions in descending order on single building elements until the budget limit is reached. In a third round a cost-optimal combination of activities on the top-ranked total set of building elements will be sought and offered as an advice to the building owner. The latter may extend the analysis over the portfolio of similar buildings to achieve a company-wide optimal 5-year budget plan.

The technique has been successfully field-tested, is regarded as an efficient decision support tool both by the RVB and by building maintenance companies facing the introduction of long-term service level agreements (main-contracting) and is taught in certification courses for building advisors. It will be implemented in CONDOR, a commercial building management system.

Introduction.

The Dutch Government Real Estate Agency (RVB) is one of the largest real estate managers in The Netherlands. The agency is responsible for approximately 2000 government buildings and terrain of the Ministry of Defence ; from approximately 350 monuments to buildings of various types like palaces, museums, offices, penitentiary institutions, bunkers, shelters, airfields and harbours, in total some 12 million gross square meter floor space. The annual maintenance budget is in the order of some 200 million €. Daily maintenance is managed via a large number of a.o. 5-7 year service level agreements via a standard specifications and conditions. Larger activities like replacement of building parts or installations are managed via a rolling 5 year planning forecast.

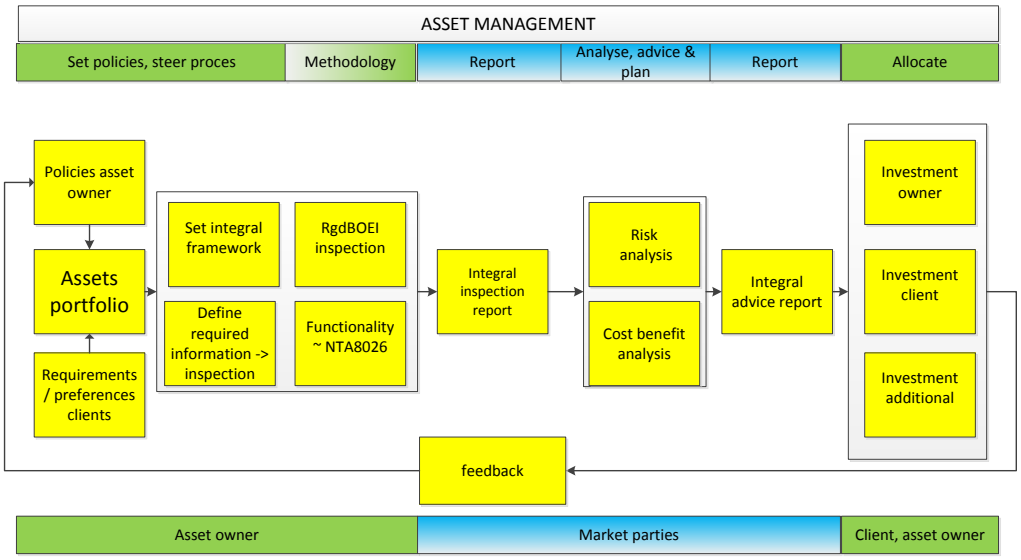


Fig. 1

Like most countries, the Netherlands has legal requirements on fire safety, health, energy consumption environmental aspects and quality (SHEEQ) of different types of buildings as laid down in the Building Regulation (Bouwbesluit). The RVB [1]introduced in 2009 the BOEI concept; every five years teams of certified inspectors are hired-in to evaluate the condition of building elements according to the Dutch norm NEN 2767 on these legal aspects (B= "brand" -> Dutch for fire, O= "onderhoud"-> Dutch for maintenance, E= energy, I= information on laws and regulations) on basis of a standard inventory of building elements. The Dutch norm NTA 8026 offers the required methodology for the link between physical asset management and these condition measurements. A hired-in building advisor subsequentially uses these inspection reports to formulate a budget proposal (integral advice report) in order to cost effectively maintain the overall real estate condition in line with the mission of the RVB (Fig. 1). As the figure suggests we are dealing here with a very lean organization of asset owner and clients that has to rely on a large number of market parties that not only are responsible for carrying out the daily maintenance and renovation activities but also provide all the required management information on condition of building elements and scenario's for planning.

In the past, the RVB had difficulties in *forecasting* a required budget for major maintenance / refurbishment / retrofitting as well as the risks of not meeting required building standards. An integral decision support tool for building management was required.

The decision problem.

Given (restricted) information on the condition of building elements and standard specifications for (service level) agreements on daily maintenance:

> *How to provide an overall steering mechanism to secure that the above integral advice reports allocate available funds cost-effectively to such maintenance / renovation activities that optimally improve the overall building condition with respect to the needs of the user and the mission of the RVB organisation?*

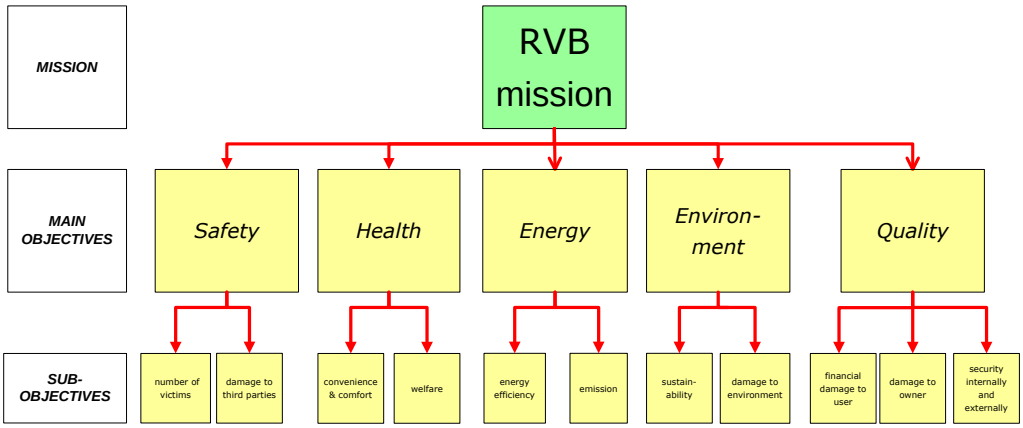


Fig. 2

In contrast with industrial asset management we are faced here with two sub-problems:

1. The mission statement in corporate real estate management is rather vague in comparison with the predefined system requirements in industry; *"The RVB contributes to the successful operation of its customers by providing efficient and effective housing solutions. With the preservation of monuments the RVB contributes in the preservation of our cultural heritage"* and cannot properly be quantified.
2. There is no clearly defined link between the functions of building elements and that of the building; preventing the use of reliability block diagrams / fault trees.

The mission statement covers five main objectives (Fig. 2) that can be properly defined and expanded into sub-objectives. For instance, safety is described as: *"This task focuses on activities that contribute to the safety of people in and around an object. A good security of people is characterized by the absence of incidents involving personal injury, as well as an adequate social safety in the operation in and around the object. Bodily injury includes both temporary or (semi-) permanent impairment of physical health, temporary or permanent disability, with fatal injury as the most extreme situation."* This objective implies two sub-objectives:

- Limiting victims; *Limiting both lethal and non-lethal, visible or invisible, physical or psychological injury, of such a character that medical treatment is necessary.*
- Limiting damage to third parties: *This includes property damage (money and resources), except the victims, in the vicinity of the property. ("Area" is an elastic concept. Though the formal responsibility mainly concerns the immediate vicinity of the property, as government housing organization, we have a greater social responsibility)*

In a similar way, the remaining objectives "Health", "Quality", "Energy" (consumption), and "Environmental aspects" are described and subdivided.

Needs for decision support models.

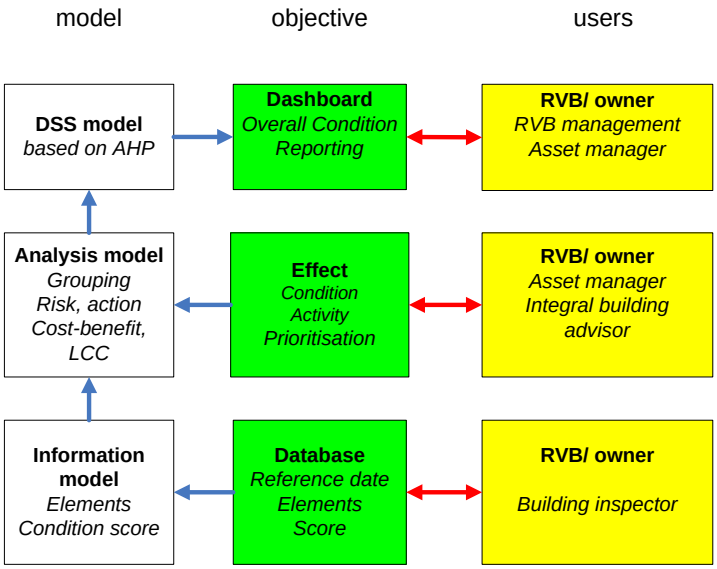


Fig. 3

In this process we recognise various actors with different needs for information (Fig. 3):

- The responsible RVB manager and, potentially, a local asset manager will be interested in overall information only. They need to be informed if the overall building condition exceeds prescribed limits whereby the range in allowed condition score will depend on the type of building (a monument versus a storage shed), the stipulations of the lease contract, the strategic position of the building in the asset portfolio, the phase in commercialisation (new versus end of life, plans for disposal), etcetera.
- The RVB specialists and the integral building advisor needs more detailed information for decision-making. They address the influence of condition scores of specific building elements on the building performance and produce motivated investment plans for major maintenance / renovation activities.
- All these activities are based on a well-defined and updated asset register. This data base provides information on the time dependency of element condition degradation thereby improving future decisions in design and maintenance. The data base is filled by the reports of the inspectors of various disciplines.

Like with all decision support systems utmost care needs to be taken to secure that the different types of information can be changed only by certified staff.

Ranking the main and sub-objectives.

Given the disparate nature, the rather vague description and the lack of objective measures, we used the AHP [2] technique to mutually rank the objectives. The AHP technique relies on pairwise comparison of each objective on a scale from 1 – 9 (Table 1):

These pairwise comparisons are carried out for all objectives to be considered, leading to the AHP matrix. The eigenvector of this matrix produces weighting factors, summing up to 1. The consistency of the individual rankings can be checked by calculating the “Consistency Ratio” that compares the ranked values with purely random judgements.

1	Equal importance.	Two factors contribute equally to the objective.
3	Somewhat more important.	Experience and judgement slightly favour one over the other.
5	Much more important.	Experience and judgement strongly favour one over the other.
7	Very much more important.	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important.	The evidence favouring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values.	When compromise is needed

Table 1

In our approach, we first presented the problem statement and the concept of the AHP technique to the RVB management team after which each team member made his / her individual rankings based on their role in the team. In a subsequent meeting the individual scores were compared with the (geometric) group averages which led to a fruitful discussion on the background of the deviations. Eventually, a group decision was reached such, from that moment on, each objective in Fig. 2 has a weighting factor that is endorsed by management.

It may well be that in future the RVB management team favours the use of different rankings for buildings of different category (say, monuments versus office buildings). Next generations of the management team may have different preferences leading to changes in the weighting factors used that far. The consequence will be that major maintenance activities from that moment on will be ranked differently in terms of cost – benefit but the systematics of the approach will remain unaffected.

Modelling a building.

In industrial reliability engineering the concept of functional decomposition is used to describe a system and analyse its unit characteristics further via failure mode effect and criticality analyses (FMECA) and, subsequentially, the system performance by reliability block diagrams (RBD's) or fault trees (FT's).

In the built environment this approach, in fact, is feasible only for building installations where the system requirements are properly defined (for instance, the required temperature, humidity and cleanliness of air in a HVAC system[3]) and the (replaceable) units that are required for fulfilling these specifications are easily defined and its reliability and repair characteristics can be estimated. For civil structures such a system model is, in general, quite complex and the only information we may use is a measure of observed condition.

Still, we observe that although most buildings are rather unique from an architectural point of view they are composed of similar or comparable building elements (sub-parts) which together are required to fulfil the necessary functions. Hence, we may follow a similar approach of functional decomposition, grouping, for instance, all components that are required for the structural aspects, the electricity supply, climate technology, transport of people and goods, … Currently, however, this clashes with the formulation of SLA contracts that are concluded with individual civil, electrical installation, heating, air conditioning, …. contractors. This led us to use solely a standard list of

building elements, part of which is given in Fig. 4, as a basis both for the 5 yearly inspections as well as for the formulation of the integral maintenance advice report.

element code	description SEL	Integral replacement value
160100	Foundation Construction (m2 footprint)	
170000	Pile foundations (m2 footprint)	
210000	facade	
222100	Interior walls	
231100	Indoor Floor Construction (incl. balcony)	
240100	stairway inside	
240800	Ladders and crampons outside	€ 2,780
270100	roof construction	
270300	Shed	€ 13,900
281200	Skeleton Part inside	
310100	Frames outside	€ 917,500
310520	Insulating glazing outside	€ 79,620
313000	doors outside	€ 10,170
323000	doors inside	€ 40,210
471100	Roofing flat roof	€ 45,540
472300	fall protection	€ 10,110
661100	Lift installation	€ 91,600
751300	Facade maintenance facility	€ 156,200
851200	Heat generation unit (eg boilers)	€ 40,440
852110	Rainwater within	€ 10,110
852400	Combined sewer drain rainwater and was	€ 32,610
853103	Water pipes fittings accessories	€ 85,630
853105	protection of drinking water (eg valve)	€ 4,160
853140	Pressure boosting system	€ 8,720
853213	Electric water heater	€ 5,810
855200	Cold generation unit central	€ 309,490
855301	Distributor / collector cooling	€ 20,540
855303	Pipeline fittings & accessories. cool	€ 47,390
855306	Expansion Cooling Services	€ 7,900
856101	Distributor / collector heating	€ 9,480
856103	Access heating pipeline	€ 147,860
856109	Expansion heating services	€ 8,000
856117	Heat emission element	€ 419,640
857200	Extractors	€ 22,220
857510	Air handling units (LBKs)	€ 142,180
857704	Fire damper	€ 32,860
857714	Ducts, app. and insulation	€ 602,920
858110	Divide / climate control box	€ 107,420
861111	Emergency Power Generator	€ 21,360
861112	Emergency Lighting Unit + cabled.	€ 15,350
861200	Grounding general	€ 1,160
861300	Wiring / electrical distribution	€ 202,200
861420	High Voltage Distribution device	€ 14,150
861500	(Main) manifold Light / Power	€ 55,870
861710	Lightning Protection System	€ 53,710
863140	Light Fixtures	€ 665,250
864210	Telephone installation	€ 137,880
864410	Data installation	€ 176,930
864620	Central antenna system	€ 1,390
865110	Fire Alarm System	€ 75,210
865130	Local fire extinguishers	€ 20,480
865135	Dry fire main	€ 10,740
865140	Fireproof conduit	€ 55,610
865210	Burglary Signaling Install.	€ 67,140
865310	Sun protection installations outside	€ 263,360
865400	Social alarms	€ 3,890
867300	Building management system	€ 3,920
874100	Toilet group	€ 13,649

Fig. 4

Information on condition.

The Dutch standard on condition of building components NEN 2767 [4] uses an ordinal scale of 1 to 6 to represent the development of ageing and wear from an initial “excellent” state to the demolition phase 6 “ very bad”:

condition	description
1	Excellent - good
2	Good
3	Reasonable - mediocre
4	Mediocre
5	Bad – very bad
6	Very bad

Table 2

These rather imprecise rankings are substantiated (

Fig. 5) by observing a defined deterioration process (say, corrosion) with a description of the “ size” (ranging from 1 to 4, small to large) and the “ intensity” (1 – 3). It will be clear from the above that this type of information (ordinal scale, imprecise description) does not lend itself for elaborate mathematical optimisation procedures.

		MAGNITUDE				
DEFECT	INTENSITY	< 2% INCIDENTAL	2 - 10 % LOCAL	10 -30 % REGULARLY	30 - 70% SIGNIFICANT	> 70 % GENERAL
SLIGHT	BEGIN	1	1	1	1	2
	EVIDENT	1	1	1	2	3
	FINAL PHASE	1	1	2	3	4
SERIOUS	BEGIN	1	1	1	2	3
	EVIDENT	1	1	2	3	4
	FINAL PHASE	1	2	3	4	5
GRAVE	BEGIN	1	1	2	3	4
	EVIDENT	1	2	3	4	5
	FINAL PHASE	2	3	4	5	6

element code	description SEL	Integral replacement value	B CB	O CB	E CB	I CB
160100	Foundation Construction (m2 footprint)		1	1		
170000	Pile foundations (m2 footprint)			1		
210000	facade		1	1	4	
222100	Interior walls		5	1		
231100	Indoor Floor Construction (incl. balcony)		1	1	4	
240100	stairway inside			1		1
240800	Ladders and crampons outside	€ 2,780		1		1
270100	roof construction		1	1		
270300	Shed	€ 13,900		5		
281200	Skeleton Part inside		1	1		
310100	Frames outside	€ 917,500	1	1	6	
310520	Insulating glazing outside	€ 79,620	1	1	4	
313000	doors outside	€ 10,170	1	1	4	
323000	doors inside	€ 40,210	1	1		
471100	Roofing flat roof	€ 45,540	1	1	4	
472300	fall protection	€ 10,110		1		1
661100	Lift installation	€ 91,600		3	5	1
751300	Facade maintenance facility	€ 156,200		2		1
851200	Heat generation unit (eg boilers)	€ 40,440		3	1	1
852110	Rainwater within	€ 10,110		2		
852400	Combined sewer drain rainwater and was	€ 32,610		2		
853103	Water pipes fittings accessories	€ 85,630		2	4	1
853105	protection of drinking water (eg valve)	€ 4,160		3		1
853140	Pressure boosting system	€ 8,720		3	5	
853213	Electric water heater	€ 5,810		3	4	1
855200	Cold generation unit central	€ 309,490		3	5	3
855301	Distributor / collector cooling	€ 20,540		3		
855303	Pipeline fittings & accessories. cool	€ 47,390		2		
855306	Expansion Cooling Services	€ 7,900		3		
856101	Distributor / collector heating	€ 9,480		2	4	
856103	Access heating pipeline	€ 147,860		2		
856109	Expansion heating services	€ 8,000		3		
856117	Heat emission element	€ 419,640		3	5	
857200	Extractors	€ 22,220		3	4	
857510	Air handling units (LBKs)	€ 142,180	2	3	3	
857704	Fire damper	€ 32,860	1	3		
857714	Ducts, app. and insulation	€ 602,920		3	4	
858110	Divide / climate control box	€ 107,420		3	3	
861111	Emergency Power Generator	€ 21,360		3		4
861112	Emergency Lighting Unit + cabled.	€ 15,350	1	3		
861200	Grounding general	€ 1,160		2		1
861300	Wiring / electrical distribution	€ 202,200		2		4
861420	High Voltage Distribution device	€ 14,150		2		1
861500	(Main) manifold Light / Power	€ 55,870		3		5
861710	Lightning Protection System	€ 53,710		2		1
863140	Light Fixtures	€ 665,250		3	2	
864210	Telephone installation	€ 137,880		3		
864410	Data installation	€ 176,930		3		
864620	Central antenna system	€ 1,390		3		
865110	Fire Alarm System	€ 75,210	4	3		
865130	Local fire extinguishers	€ 20,480	3	3		
865135	Dry fire main	€ 10,740	1	3		
865140	Fireproof conduit	€ 55,610		3		3
865210	Burglary Signaling Install.	€ 67,140		3		
865310	Sun protection installations outside	€ 263,360		3	1	
865400	Social alarms	€ 3,890		2		
867300	Building management system	€ 3,920		3	1	
874100	Toilet group	€ 13,649		1		

Fig. 5

Fig. 6

RVB experts prescribe the type of inspection (B,O,E,I) to be carried out. The observed NEN 2767 conditions are stored (Fig. 6) in the AHP software package. Note that an individual element may have different scores for each aspect. For instance, the façade scores “excellent” for the aspects “fire” and “maintenance” but has a ranking 4 (mediocre) for “energy”. These figures are to be regarded as the final, overall judgement from one of the inspection teams; in the associated report this figure is substantiated by an extensive description of the observed phenomena.

If all inspection reports are available and the BOEI condition scores filled in as described above, these conditions need to be linked with the (sub)objectives. With the previously described lack of system model this task is performed by an RVB expert and secured in the software.

element code	description SEL	Integral replacement value	B CB	O CB	E CB	I CB	SUB-OBJECTIVES RANKING	D1.1 limit # victims	D1.2 limit damage to 3rd parties	D2.1 convenience & comfort	D2.3 welfare	D3.1 limit financial damage to owner	D3.2 limit damage to owner	security internally externally	D4.1 energy efficiency	D4.2 emission	D5.1 durability	D5.2 damage to environment
160100	Foundation Construction (m2 footprint)		1	1			0.27	1				1						
170000	Pile foundations (m2 footprint)			1			0.09					1	1					
210000	facade		1	1	4		2.54	1	1	4	4	1	1	1	4	4	4	1
222100	Interior walls		5	1			1.10	5				1		1				
231100	Indoor Floor Construction (incl. balcony)		1	1	4		2.38	1		4	4	1	1	1	4	4	4	
240100	stairway inside			1		1	0.09					1	1					
240800	Ladders and crampons outside	€ 2,780		1		1	0.03						1					
270100	roof construction		1	1			0.39	1	1			1	1	1				
270300	Shed	€ 13,900		5			0.46					5	5					
281200	Skeleton Part inside		1	1			0.39	1	1			1	1	1				
310100	Frames outside	€ 917,500	1	1	6		3.42	1		6	6	1	1	1	6	6	6	
310520	Insulating glazing outside	€ 79,620	1	1	4		2.47	1	1	4	4	1	1	1	4	4	4	
313000	doors outside	€ 10,170	1	1	4		2.38	1		4	4	1	1	1	4	4	4	
323000	doors inside	€ 40,210	1	1			0.27	1				1		1				
471100	Roofing flat roof	€ 45,540	1	1	4		1.19	1				1	1		4	4	4	
472300	fall protection	€ 10,110		1		1	0.18		1			1	1					
661100	Lift installation	€ 91,600		3	5	1	1.39					3	3		5	5	5	
751300	Facade maintenance facility	€ 156,200		2		1	0.27		1			2	2					
851200	Heat generation unit (eg boilers)	€ 40,440		3	1	1	0.96		1	1	1	3	3		1	1	1	1
852110	Rainwater within	€ 10,110		2			0.19					2	2					
852400	Combined sewer drain rainwater and was	€ 32,610		2			0.33					2	2					2
853103	Water pipes fittings accessories	€ 85,630		2	4	1	0.27		1			2	2					
853105	protection of drinking water (eg valve)	€ 4,160		3		1	0.37		1			3	3					
853140	Pressure boosting system	€ 8,720		3	5		1.39					3	3		5	5	5	
853213	Electric water heater	€ 5,810		3	4	1	1.26		1			3	3		4	4	4	
855200	Cold generation unit central	€ 309,490		3	5	3	3.09			5	5	3	3		5	5	5	3
855301	Distributor / collector cooling	€ 20,540		3			0.28					3	3					
855303	Pipeline fittings & accessories. cool	€ 47,390		2			0.19					2	2					
855306	Expansion Cooling Services	€ 7,900		3			0.28					3	3					
856101	Distributor / collector heating	€ 9,480		2	4		1.08					2	2		4	4	4	
856103	Access heating pipeline	€ 147,860		2			0.19					2	2					
856109	Expansion heating services	€ 8,000		3			0.28					3	3					
856117	Heat emission element	€ 419,640		3	5		2.88			5	5	3	3		5	5	5	
857200	Extractors	€ 22,220		3	4		2.36			4	4	3	3		4	4	4	
857510	Air handling units (LBKs)	€ 142,180	2	3	3		2.25	2		3	3	3	3		3	3	3	
857704	Fire damper	€ 32,860	1	3			0.49	1				3	3					
857714	Ducts, app. and insulation	€ 602,920		3	4		1.17					3	3		4	4	4	
858110	Divide / climate control box	€ 107,420		3	3		1.84			3	3	3	3	3	3	3	3	
861111	Emergency Power Generator	€ 21,360		3		4	1.47	4	4			3	3	3				
861112	Emergency Lighting Unit + cabled.	€ 15,350	1	3			0.49	1				3	3	3				
861200	Grounding general	€ 1,160		2		1	0.48	1	1			2	2	2				
861300	Wiring / electrical distribution	€ 202,200		2		4	1.37	4	4			2	2	2				
861420	High Voltage Distribution device	€ 14,150		2		1	0.48	1	1			2	2	2				
861500	(Main) manifold Light / Power	€ 55,870		3		5	1.76	5	5			3	3	3				
861710	Lightning Protection System	€ 53,710		2		1	0.48	1	1			2	2					
863140	Light Fixtures	€ 665,250		3	2		1.61			3	3	3	3	3	2	2	2	
864210	Telephone installation	€ 137,880		3			0.17					3		3				
864410	Data installation	€ 176,930		3			0.17					3						
864620	Central antenna system	€ 1,390		3			0.17					3						
865110	Fire Alarm System	€ 75,210	4	3			1.11	4				3	3					
865130	Local fire extinguishers	€ 20,480	3	3			0.90	3				3	3					
865135	Dry fire main	€ 10,740	1	3			0.49	1				3	3					
865140	Fireproof conduit	€ 55,610		3		3	1.17	3	3			3	3					
865210	Burglary Signaling Install.	€ 67,140		3			0.17					3		3				
865310	Sun protection installations outside	€ 263,360		3	1		1.37			3	3	3	3		1		1	
865400	Social alarms	€ 3,890		2			0.53	2				2						
867300	Building management system	€ 3,920		3	1		1.39			3	3	3	3	3	1	1	1	
874100	Toilet group	€ 13,649		1			0.09					1	1					

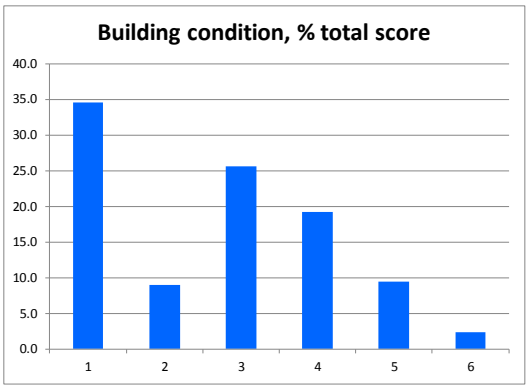
Fig. 7

Fig. 7 shows an example of such a grouped list of element conditions. Note that an individual element may result in several, not necessarily identical, inspection scores under the various sub-objectives.

At this point we can evaluate the list of scores for each sub-objective. Fig. 8 shows, for example, 25 scores under the heading S-O 1.1 “limit # victims”; 16 at condition 1, 2 at condition 2, 2 at condition 3, 3 at 4, 2 at 5 and zero at condition 6. An average representation then is 1.92, although this figure is debatable since we deal here with ordinal scales; the distribution of the condition scores is more relevant. This process is repeated for the second sub-objective S-O 1.2 “limit damage to 3rd parties” with 17 scores.

These results are aggregated at the objective level “safety” using the (AHP) weighting scores[1] 0.7 for S-O 1.1 and 0.3 for S-O 1.2, respectively. This leads to a weighted number of scores ($Nscores_{weighted} = \sum_{i=1}^{2} N_{O1.i} * weighting\ factor_{O1.i}$) of 22.6, a similarly weighted average of 1.86 and weighted number of individual scores of 15.1, 1.4, 1.7, 2.7, 1.7 and 0 for the categories 1 – 6. Repeating this process for the remaining objectives, we are in a position to aggregate these scores

[1] The AHP weighting factors in this paper are for illustrative purposes only.



TOTAAL		
OVERALL SCORE		2.80
weighted number		21.1
average		2.80
% # of condition	1	34.6
% # of condition	2	9.0
% # of condition	3	25.6
% # of condition	4	19.2
% # of condition	5	9.4
% # of condition	6	2.3

OBJECTIVES	O1 SAFETY		O2 HEALTH		O3 USABILITY			O4 ENERGY EFFICIENCY		O5 ENVIRONMENT	
WEIGHTING FACTOR	0.30		0.30		0.12			0.04		0.20	
SCORE	1.86		3.71		2.23			3.69		2.99	
weighted number	22.6		14.0		47.5			19.7		14.4	
average	1.86		3.7		2.2			3.7		3.0	
w. # condition 1	15.1		1.0		13.2			2.7		2.7	
w. # condition 2	1.4		0.0		9.9			1.0		1.0	
w. # condition 3	1.7		5.0		23.6			2.0		1.7	
w. # condition 4	2.7		5.0		0.0			9.0		5.9	
w. # condition 5	1.7		2.0		0.8			4.0		2.6	
w. # condition 6	0.0		1.0		0.0			1.0		0.7	

SUB-OBJECTIVES	S-O1.1 limit # victims	S-O1.2 limit damage to 3rd parties	S-O2.1 convenience & comfort	S-O2.2 wellfare	S-O3.1 limit financial damage to owner	S-O3.2 limit damage to owner	security internally externally	S-O4.1 energy efficiency	S-O4.2 emission	S-O5.1 durability	S-O5.2 damage to environment
WEIGHTING FACTOR	0.70	0.30	0.50	0.50	0.50	0.30	0.20	0.70	0.30	0.65	0.35
SCORE	1.92	1.71	3.71	3.71	2.30	2.30	1.95	3.65	3.79	3.65	1.75
number	25	17	14	14	57	50	20	20	19	20	4
average	1.92	1.71	3.71	3.71	2.30	2.30	1.95	3.65	3.79	3.65	1.75
#condition 1	16	13	1	1	15	13	9	3	2	3	2
#condition 2	2	0	0	0	12	11	3	1	1	1	1
#condition 3	2	1	5	5	29	25	8	2	2	2	1
#condition 4	3	2	5	5	0	0	0	9	9	9	0
#condition 5	2	1	2	2	1	1	0	4	4	4	0
#condition 6	0	0	1	1	0	0	0	1	1	1	0

Fig. 8

at building level. The building reaches an overall score of 2.7, 35 % of the observed conditions are at the level 1 “Excellent – good”, but we also note some 25% at level 3 “Reasonable – mediocre” and some 2 % at the level 6 “Very bad”.

The advisor uses this information in his/her integral advice report, in three subsequent steps:

1. The building owner needs to adhere to building regulations and will normally agree a minimum condition level in the lease for a specific type of building. Any violation of this type needs to be solved or further negotiated. The advisor will use the software package to easily observe such intolerable conditions. This will lead to a first set of indispensable maintenance activities, the costs of which form a lower threshold.
2. The advisor will observe a multitude of conditions that warrant improvement. Rather than following his own technical insight, the advisor now is forced to use a ranking that is provided by the software package; the importance of a given NEN condition score depends on:
    a. The number of sub-objectives that are involved.
    b. The relative value to the RVB mission as expressed by the AHP weighting scores. For each element: $\sum_{j=1}^{\#\ objectives}(wf_{o\ j}\sum_{i=1}^{\#\ so} condition_{so\ i} * wf_{so\ i})$
    c. If the advisor proposes one of these activities he has to add the costs to the budget which normally shows a ceiling that determines the total financially accepted scope and thus provides a cut-off point.
    d. Note that the ranking at condition scores is a starting point only for a more detailed analysis that is required in the in the integral advice report. The advisor has to

describe the link between observed / in near future expected conditions and the risks of not meeting functionality or building standards. A total lifecycle cost evaluation has to be provided.

3. The advisor will use this crude list to evaluate a more integral evaluation. In practice the execution of one specific activity may lead to the opportunity of executing another activity at much lower costs. For instance, if one replacement requires the use of scaffolding, he may study other activities that could benefit from the then existing scaffolding and thus can cost-effectively be executed.

description SEL	Integral replacement value	B CB	O CB	E CB	I CB	SUB-OBJECTIVES RANKING	D1.1 limit # victims	D1.2 limit damage to 3rd parties	D2.1 convenience & comfort	D2.3 welfare	D3.1 limit financial damage to owner	D3.2 limit damage to owner	security internally externally	D4.1 energy efficiency	D4.2 emission	D5.1 durability	D5.2 damage to environment
Frames outside	€ 917,500	1	1	6		3.13	1		6	6	1	1	1	6	6	6	
Cold generation unit central	€ 309,490		3	5	3	2.85			5	5	3	3		5	5	5	3
Heat emission element	€ 419,640		3	5		2.64			5	5	3	3		5	5	5	
facade		1	1	4		2.35	1	1	4	4	1	1	1	4	4	4	1
Insulating glazing outside	€ 79,620	1	1	4		2.28	1	1	4	4	1	1	1	4	4	4	
Indoor Floor Construction (incl. balcony)		1	1	4		2.19	1		4	4	1	1	1	4	4	4	
doors outside	€ 10,170	1	1	4		2.19	1		4	4	1	1	1	4	4	4	
Extractors	€ 22,220		3	4		2.16			4	4	3	3		4	4	4	
Air handling units (LBKs)	€ 142,180	2	3	3		2.11	2		3	3	3	3		3	3	3	
(Main) manifold Light / Power	€ 55,870		3		5	1.76	5	5			3	3	3				
Divide / climate control box	€ 107,420		3	3		1.69			3	3	3	3	3	3	3	3	
Light Fixtures	€ 665,250		3	2		1.52			3	3	3	3	3	2	2	2	
Emergency Power Generator	€ 21,360		3		4	1.47	4	4			3	3	3				
Wiring / electrical distribution	€ 202,200		2		4	1.37	4	4			2	2	2				
Building management system	€ 3,920		3	1		1.34			3	3	3	3	3	1	1	1	
Sun protection installations outside	€ 263,360		3	1		1.33			3	3	3	3		1		1	
Fireproof conduit	€ 55,610		3		3	1.17	3	3			3	3					

Fig. 9 Example of ranking

The ranked list (Fig. 9) shows that the replacement of all window frames, at a cost of € 917500, leads to the most significant contribution since they score “very bad” (condition 6) w.r.t. energy and image.

The cold generator unit is a second candidate, followed by replacement of all radiators (heat emission element). Obviously, the selection of candidates requires more information than these simple numbers. Take the window frames with an investment of around 1 million euro, they will last for another 30 – 50 years; will the building be used that long? Are other measures available that, although not bringing the condition back to 1 but say to 3 commercially more interesting?

description SEL	Integral replacement value	B CB	O CB	E CB	I CB	SUB-OBJECTIVES RANKING	D1.1 limit # victims	D1.2 limit damage to 3rd parties	D2.1 convenience & comfort	D2.3 welfare	D3.1 limit financial damage to owner	D3.2 limit damage to owner	security internally externally	D4.1 energy efficiency	D4.2 emission	D5.1 durability	D5.2 damage to environment
Frames outside	?	1	1	3		1.72	1		3	3	1	1	1	3	3	3	
Cold generation unit central	€ 309,490		3	5	3	2.85			5	5	3	3		5	5	5	3
Heat emission element	€ 419,640		3	5		2.64			5	5	3	3		5	5	5	
facade		1	1	4		2.35	1	1	4	4	1	1	1	4	4	4	1
Insulating glazing outside	€ 79,620	1	1	4		2.28	1	1	4	4	1	1	1	4	4	4	
Indoor Floor Construction (incl. balcony)		1	1	4		2.19	1		4	4	1	1	1	4	4	4	
doors outside	€ 10,170	1	1	4		2.19	1		4	4	1	1	1	4	4	4	

Fig. 10 condition window frames from 6 to 3

Fig. 10 shows the window frame condition change from 6 to 3 (say, using double window frames). The overall building score (Fig. 11) improves from 2.8 to 2.7 at maybe half the original costs.

TOTAAL		
OVERALL SCORE		2.71
weighted number		21.1
average		2.71
% # of condition	1	34.6
% # of condition	2	9.0
% # of condition	3	27.9
% # of condition	4	19.2
% # of condition	5	9.4
% # of condition	6	0.0

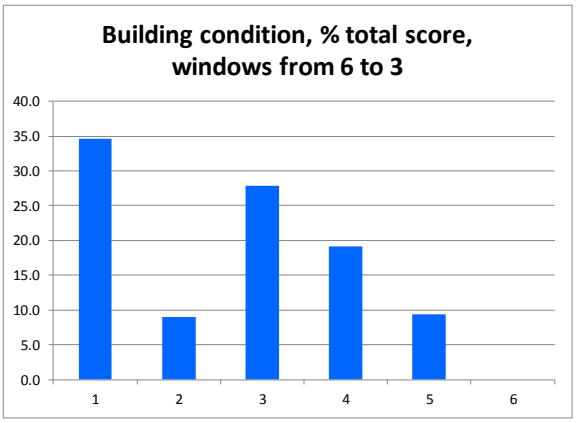


Fig. 11 Results at building level.

element code	description SEL	Integral replacement value	B CB	O CB	E CB	I CB	SUB-OBJECTIVES RANKING	D1.1 limit # victims	D1.2 limit damage to 3rd parties	D2.1 convenience & comfort	D2.3 wellfare	D3.1 limit financial damage to owner	D3.2 limit damage to owner	security internally externally	D4.1 energy efficiency	D4.2 emission	D5.1 durability	D5.2 damage to environment
310100	Frames outside	€ 917,500	1	1	6		3.13	1		6	6	1	1	1	6	6	6	
855200	Cold generation unit central	€ 309,490		1	1	1	0.64			1	1	1	1		1	1	1	1
856117	Heat emission element	€ 419,640		1	1		0.56			1	1	1	1		1	1	1	
210000	facade		1	1	4		2.35	1	1	4	4	1	1	1	4	4	4	1

Fig. 12 Replacing cold generation unit and radiators

If we leave the window frames at the existing condition but spend some 730 k€ on replacing the cold generation unit and the radiators (Fig. 12) the overall building score (Fig. 13)improves from 2.80 to 2.5 but the owner still has to live with window frames that do not meet current requirements on energy consumption.

TOTAAL		
OVERALL SCORE		2.50
weighted number		21.1
average		2.50
% # of condition	1	40.5
% # of condition	2	9.0
% # of condition	3	24.3
% # of condition	4	19.2
% # of condition	5	4.7
% # of condition	6	2.3

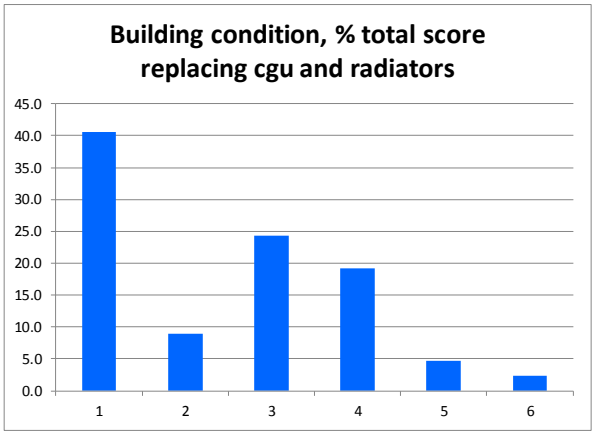


Fig. 13 Results at building level.

The building advisor will discuss these alternatives with the RVB upon which the latter will take specific decisions. The resulting change in element condition codes will be recorded in the database.

Conclusions and further work.

1. In comparison with industrial maintenance, Corporate Real Estate Management in general lacks both quantified and measurable requirements at system level, proper system modelling and information on failure behaviour of system components.

2. The mission of the Dutch Government Real Estate Agency (RVB) can be subdivided in five main objectives (safety, health, quality, energy and environmental aspects); some of which can be further divided in sub-objectives. Using the AHP pairwise comparison technique the members of the responsible RVB management team defined subjective rankings that express their views on the individual importance of these items.
3. Information on the condition of many building elements is obtained from five yearly inspection reports where teams of hired-in certified inspectors score elements in four categories ("fire", "maintenance", "energy", "laws and regulations") with condition numbers according to an existing Dutch norm N2767 subsequent to a detailed inspection report.
4. A hired-in building advisor subsequentially uses these inspection reports to formulate a budget proposal (integral advice report) in order to cost effectively maintain the overall real estate condition in line with the mission of the RVB using a newly developed software package. In this package the AHP scores are used as weighting factors for decision support; RVB experts prescribe the link between condition scores and sub-objectives.
5. The new package provides a transparent overview of these conditions at building element level and determines their effect on the sub- and main mission objectives. The building advisor easily identifies compulsory actions (elements for which the condition clashes with rules or contract stipulations) that form the lower basis of a multiannual maintenance budget. He/she may easily rank elements in terms of contribution to the mission objectives and use this ranking in identifying a series of cost-effective maintenance solutions. The budget ceiling for a given object in a given time period provides a natural cut-off point. Having such a list, a third optimization round will identify combinations of maintenance activities for which the costs of combined execution provides a cost-effective opportunity.
6. The package covers the needs of all involved parties.
    - For RVB management it calculates an overall building performance (dashboard function) that may be used to classify building categories and functions as a key performance indicator; deviations of which can easily be reported.
    - For RVB experts and building advisors it provides decision support on cost-effective maintenance following the mission of the RVB (the analysis function).
    - The condition scores of inspection results and implemented maintenance activities are properly registered in the database.
7. This AHP approach is now used on a trial basis in the RVB organisation and is taught at university courses the advisor has to follow in order to become certified. First results are promising; the advices produced are sometimes unexpected compared with a traditional purely technical approach but are understood and accepted by building experts and contractors.
8. The charm of the method lies with its structure and integral character. It allows the RVB management to steer activities by changing the AHP weighting factors for different classes of buildings or different political situations without sacrificing the structured approach. It ensures that all building elements are properly taken into account with respect to the mission of the RVB independent from cultural or purely traditional technical preferences. By using this system, the RVB will automatically build up a reliable data base on the time dependent behaviour of building elements and thereby contributes to a learning organisation.

9. This concept is planned to be integrated with a commercial building maintenance information system (Condor) making this new approach available to the corporate real estate market as a whole.

In the meantime the AHP concept has successfully been used in another decision support tool EPI-CREM [5], in this case for energy performance optimisation. The AHP approach in obtaining consensus between disparate parties (principal versus building contractors) also showed to be effective in system oriented contract management. In one case, 18 (competing) contractors took part in AHP rankings at three organisational levels; business management, contract manager and contract administrator. The outcome of this study was that parties agreed that the original number of 176 risk factors could be aggregated to 6 only and 24 conditions / terms into 15; definitions and objectives were adapted and KPI's for service level agreements mutually accepted.

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