IALA GUIDELINE

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COST COMPARISON METHODOLOGY OF BUOY TECHNOLOGIES

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Association Internationale de Signalisation Maritime

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1. BACKGROUND

Marine Aids to Navigation (AtoN) services are faced with a choice of buoy technologies. These technologies employ various materials and manufacturing methods. A change in buoy technology might allow a service to reduce its operating costs. However, the decision to change from the existing buoy technology to a different technology must be made with care.

1.1. SCOPE

This paper sets out some points which should assist the decision making and recommend the use of Net Present Value (NPV) analysis for financial evaluation.

2. EXAMPLES OF DIFFERENT BUOY TECHNOLOGIES

Various materials are used for the manufacture of floating AtoN buoys. These include:

- Steel
- Aluminium
- Plastics of various types (reference IALA Guideline *G1006 Plastic Buoys*).

These materials may be used alone. They can also be used in combination to manufacture buoys which combine the benefits of different materials. For example:

- Steel buoy hull with aluminium tower
- Rotationally moulded plastic buoy float with steel centre tube and aluminium tower
- All plastic hull and tower, with internal metal structural members
- Aluminium buoy with plastic foam filling within the hull
- Glass Reinforced Polyester (GRP) buoy hull with steel or aluminium tower

These are simply a few of the possible choices. The material choices are influenced by the size of buoy required, and by the environmental conditions under which it must operate. Changing to a different technology may offer the AtoN operating authority a reduction in overall costs, via reduction in servicing/support costs or reduction in first costs. As an example, Example 1 (see section 5.1) presents technical factors relating to rotationally moulded polyethylene buoys.

This subject may also be extended to compare conventional buoys with fixed beacons (usually single pile) or spar buoys which are moored at the seabed with a universal joint or short chain. These are known by various names, including “spar buoys”, “resilient beacons”, “buoyant beacons” and “elastic beacons”. The preferred term is “buoyant beacon”. This type of buoy can offer potential cost savings by reducing the frequency of mooring inspection and replacement, if local tidal regime and water depth allow the use of these alternatives. See Example 2 in section 5.2.

3. PRIMARY POINTS FOR CONSIDERATION

The first step in comparing buoy technologies is determination of the level of service required. The technologies being compared should achieve the defined service level. If full compliance is not achieved, confirm if a deviation in service level is acceptable. The choice of buoy technology could affect the type of mooring hardware, signal equipment, and power systems required. The complete buoy system should be considered when conducting this analysis. In some cases, the full cost advantage may only be realized if a smaller servicing vessel can be used or if on-shore maintenance facilities can be closed. Realizing these savings may require the authority to replace the entire fleet of old buoys with new.

The following questions should be addressed when comparing different technologies.

3.1. EXISTING INFRASTRUCTURE

- Servicing vessel capabilities
- On-shore maintenance facilities (blasting, painting, etc.)
- On-shore logistics capabilities (storage, handling, etc.)

3.2. AtoN SIGNAL

- Does the new buoy provide an adequate day-mark?
- Is it capable of carrying a lantern with the required range and other required equipment and the associated power system?
- Is the motion of the buoy on station too rapid or of too great angular displacement for the AtoN function to be clear to the mariner (e.g., vertical divergence)?
- Is the focal height sufficient for local sea conditions?
- Can a suitable radar reflector be mounted?
- In summary, how well does the new buoy meet the service requirements?

3.3. SERVICEABILITY

- Is it possible to connect a suitable mooring to the buoy?
- Do the lifting and mooring eyes permit safe handling of the buoy as required by the Authority?
- Is the buoy's motion acceptable for maintenance personnel to work on the buoy?
- Does the design adequately permit inspection/testing of the structural integrity of the buoy?

3.4. LOCAL CONDITIONS

- In ice conditions will the buoy be suitable?
- If self-coloured materials (usually plastic) are used how long will the coloured surface last in the local UV environment?
- Extreme local conditions (temperature, wave conditions, etc.) should be taken into consideration with the choice of buoy.

3.5. ENVIRONMENTAL CONSIDERATIONS

Choice of technology should minimize the impact on the environment. Refer to IALA Guideline *G1036 Environmental Considerations in Aids to Navigation Engineering.*

3.6. SERVICE INTERVALS

- At what interval must the day-mark components be replaced to retain correct signal colours?
- What are the inspection and maintenance intervals of component parts, mooring hardware, power system and signal equipment?
- How often must the new and existing buoys be visited to maintain the lantern, power system, mooring etc.?
- It is important to identify the critical items that will wear out and to define the maintenance periods for the new buoy.
- How long will the new buoy remain on station before removal ashore for major servicing is necessary, and how does this compare with existing buoys?

3.7. PURCHASE COSTS

- What are the costs of the purchase of the existing buoys?
- What are the costs of the purchase of the new buoys?
- What is the anticipated life expectancy of the old versus the new buoys?
- What are the costs of spares to cover planned maintenance and to provide breakdown cover?

3.8. MAINTENANCE COSTS

- What time and resources are required to maintain the existing buoy – and how much does it cost?
- What time and resources will be required to maintain the new buoy – and how much will it cost?
- Will there be any savings in the servicing vessel costs from using a different buoy technology?
- Will there be a saving in vessel time at each servicing visit?
- Will the number of service visits be reduced?
- Will the same vessels/facilities be used for the new buoys?
- What Health and Safety regulations accompany the new technology?
- Will the new buoy mean a reduction in mooring component costs?
- Will the new technology require specialized staff training?

3.9. USE OF CONTRACTORS

- Steel can be repaired “anywhere”.

  Structural steel specialists are widely available.
- Aluminium repair may be difficult away from industrial centres.
- High specification paint systems for steel and aluminium require sophisticated surface preparation and application facilities.
- Repairs to some plastics may require the contractor to have special tools and skills.
- How will this affect the total costs?

4. FINANCIAL ANALYSIS AND THE NPV METHOD

Financial analysis for the comparison of different buoy strategies should preferably use the net present value (NPV) method. NPV analysis is an approach used in capital budgeting where the present value of cash inflow is subtracted from the present value of cash outflows. It is accepted internationally as a method of financial analysis to support decision making. For most buoy decision analysis there will be the comparison of costs, but income could arise from sales of redundant items or from marketing “spare” ship time.

Explanation of NPV theory is not given here. The reader is referred to the Internet or to textbooks, which can be found on the topic in most languages. However, the following points are important to keep in mind:

- Choice of the time period of the NPV analysis
- Sensitivity of the analysis to the time period selected, discount rate chosen and other key assumptions
- It is important to capture all of the costs during the NPV period (purchase, maintenance, disposal, etc.).
- Previously-spent sums (sunk costs) should not be included in the analysis.

5. EXAMPLES

Examples of the application of the above methodology are provided for reference purposes only.

5.1. EXAMPLE 1 – AMSA AUSTRALIA

This example shows the use of NPV analysis for making a decision on the best buoy technology to employ.

AMSA (Australian Maritime Safety Authority) has recently performed a cost benefit analysis of options for replacement buoys in Australia, taking into consideration a number of presently available plastic alternatives to their current steel buoys. The analysis resulted in a decision to continue with steel buoys for the next five years.

Whilst the decision to stick with steel buoys is very interesting in itself, the methodology used to arrive at this decision is even more interesting for other AtoN authorities.

The approach used for evaluating the capital cost savings was as follows:

1 Select which scenarios to analyse.

2 Define any basic assumptions made for the analysis.

3 Select a timeframe for the analysis.

4 Calculate the initial replacement costs.

5 Calculate the maintenance costs each year.

6 Calculate the net present value (NPV) of all costs within the selected timeframe.

7 Compare the NPV of each scenario.

5.1.1. SCENARIOS TO ANALYSE

The following scenarios were selected for the AMSA analysis:

1 Continue to use the current design of buoys of steel construction.

OR

2 Change to plastic construction buoys which have reduced maintenance requirements.

5.1.2. Basic assumptions

The following basic assumptions were made for the analysis:

- Costs common to all scenarios can be omitted.
- Maintenance cycle of steel hull buoys requires purchase of 1.5 times the number in service (spares ratio).
- Maintenance cycle of plastic hull buoys requires purchase of 1.25 times the number in service.

5.1.3. Time frame

A time frame of 20 years was selected.

5.1.4. Calculate initial replacement costs

The following factors were taken into consideration for calculating the initial costs:

- Unit cost
- Maintenance spares (proportion in-store)
- Installation components/fittings
- Cost of ship time for installation

5.1.5. Calculate maintenance costs

While calculating the maintenance costs each year, the following factors were considered:

- Minor maintenance costs at intervals of 2 years
- Major maintenance costs at intervals of 4 and 6 years
- Buoy replacement costs at intervals of 10 years (buoy lifetime)

In each case, the costs were split into the cost of ship time and other costs (materials and services).

5.1.6. Calculate NPV

A standard methodology for calculating NPV was used.

5.1.7. Compare the NPV of each scenario

Comparing the NPV of each scenario revealed what potential capital cost savings could be obtained for each scenario relative to the present scenario.

A spreadsheet example of this basic NPV methodology is found at the end of this example.

The above mentioned factors can more or less be characterized as direct cost drivers. In addition to these, there may be a number of indirect cost drivers such as workshop facilities that may be affected by the alternative scenarios.

(Information provided courtesy of AMSA)

Table 1 Spread Sheet example

Item	Current Steel Buoy	Buoy A	Buoy B	Buoy C	Buoy D
Initial Costs					
Unit Cost	9600	9700	14000	25000	55000
Maintenance Spares (proportion in store)	0,5	0,25	0,25	0	0
Installation components/fittings	6300	6300	6300	1800	1800
Ship time for installation (days)	0,5	0,5	0,5	2	2
Installation costs	2550	2550	2550	10200	10200
Daily Ship Cost	5100				
Maintenance Costs					
Minor maintenance costs at interval of:- (years)	2	2	2	2	2
Ship Time (days)	0,5	0,5	0,5	0,5	0,5
Ship Cost	2550	2550	2550	2550	2550
Other Costs (materials & services)	2700	2700	2700	1500	1500
Major maintenance costs at interval of:- (years)	4	4	4	6	6
Ship Time (days)	0,5	0,5	0,5	1	1
Ship Cost	2550	2550	2550	5100	5100
Other Costs (materials & services)	3000	2400	2400	3000	3000
Buoy Changeout costs at interval of:- (years)				10	10
Ship Time (days)				2	2
Ship Cost				10200	10200
Other Costs (materials & services)				6000	9000

Year	Current	Buoy A	Buoy B	Buoy C	Buoy D
0	-23250	-20975	-26350	-37000	-67000
1	0	0	0	0	0
2	-5250	-5250	-5250	-4050	-4050
3	0	0	0	0	0
4	-5550	-4950	-4950	-4050	-4050
5	0	0	0	0	0
6	-5250	-5250	-5250	-8100	-8100
7	0	0	0	0	0
8	-5550	-4950	-4950	-4050	-4050
9	0	0	0	0	0
10	-5250	-5250	-5250	-16200	-19200
11	0	0	0	0	0
12	-5550	-4950	-4950	-8100	-8100
13	0	0	0	0	0
14	-5250	-5250	-5250	-4050	-4050
15	0	0	0	0	0
16	-5550	-4950	-4950	-4050	-4050
17	0	0	0	0	0
18	-5250	-5250	-5250	-8100	-8100
19	0	0	0	0	0
20	-5550	-4950	-4950	-16200	-19200
Total	-77250	-71975	-77350	-113950	-149950
NPV at					
5%	**-56.033**	**-52.023**	**-57.398**	**-80.619**	**-113.591**
10%	**-45.084**	**-41.709**	**-47.084**	**-64.214**	**-95.817**

Note - The figures shown are indicative of the figures obtained by AMSA but, for commercial reasons, are not the actual figures used.

5.2. EXAMPLE 2 - JCG JAPAN

This shows an alternative method of financial analysis in the comparison of buoys and resilient beacons.

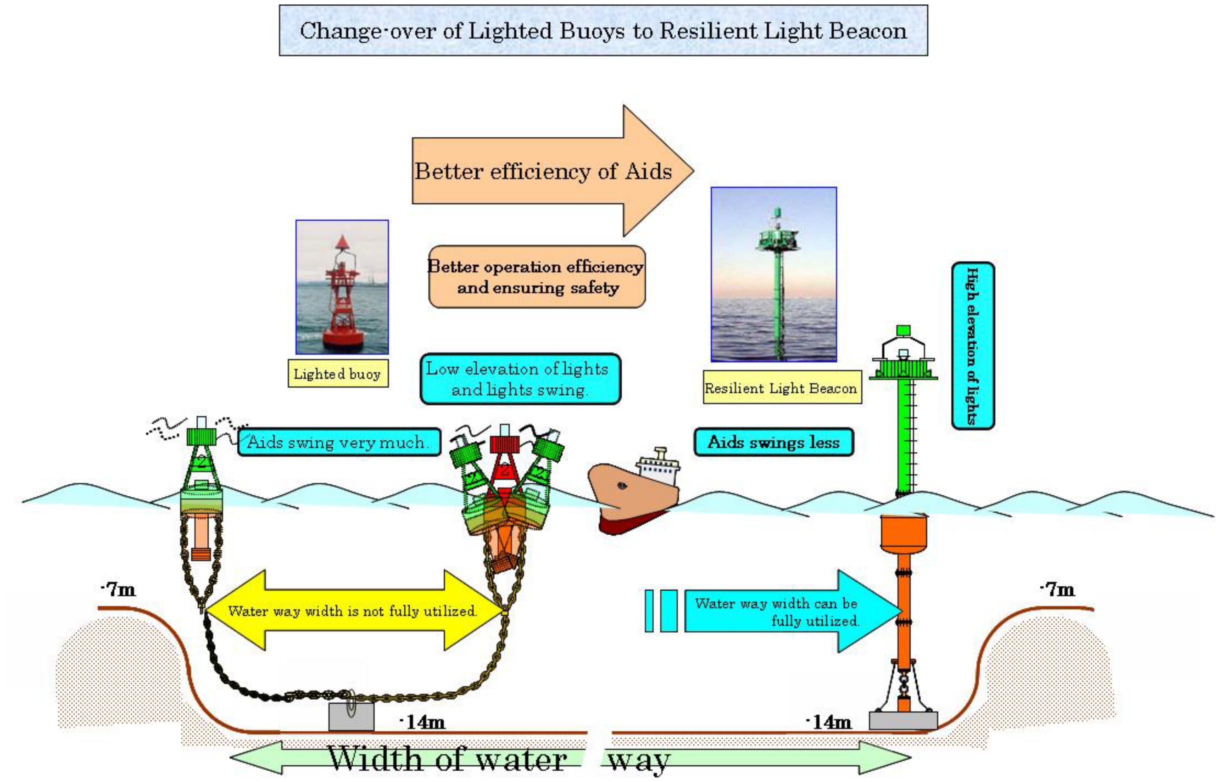

Figure 1 Changeover of lighted buoys to resilient light beacon

Table 2 Lighted buoy types L-1, L-2 & L-3

1 L-1 type Lighted buoy

Item	Standard	Unit price	Service life	Depth 10 m				Depth 15 m				Depth 20 m				Depth 25m				Depth 30 m			
				No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost
Buoy Hull	L-1	3,790	20	1.0	3,790.0		189.5	1.0	3,790.0		189.5	1	3,790.0		189.5	1	3,790.0		189.5	1	3,790.0		189.5
Mooring chain	32φ25m	487	8	0.5	243.5		30.4	1.0	487.0		60.9	1.2	584.4		73.1	1.5	730.5		91.3	2	974.0		121.8
Bridle chain	30φ12m	267	8	1.0	267.0		33.4	1.0	267.0		33.4	1	267.0		33.4	1	267.0		33.4	1	267.0		33.4
Swivel	32φ	51	6	1.0	51.0		8.5	1.0	51.0		8.5	1	51.0		8.5	1	51.0		8.5	1	51.0		8.5
Shackle	32φ	35	6	5.0	175.0		29.2	5.0	175.0		29.2	6	210.0		35.0	6	210.0		35.0	6	210.0		35.0
Shinker	RC4t	246	25	1.0	246.0		9.8	1.0	246.0		9.8	1	246.0		9.8	1	246.0		9.8	1	246.0		9.8
Installation cost	Construction	1,200	2	1.0		1200	600.0	1.0		1200	600.0	1		1,200	600.0	1		1200	600.0	1		1200	600.0
Initial Capital cos	Buoy Depot	600	2	1.0		600	300.0	1.0		600	300.0	1		600	300.0	1		600	300.0	1		600	300.0
Total					4,773	1,800	1,201		5,016	1,800	1,231		5,148	1,800	1,249		5,295	1,800	1,268		5,538	1,800	1,298

2 L-2type Lighted buoy

Item	Standard	Unit price	Service life	Depth 10 m				Depth 15 m				Depth 20 m				Depth 25 m				Depth 30 m				Depth 35 m			
				No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost
Buoy Hull	L-2	4,472	20					1.0	4,472.0		223.6	1	4,472.0		223.6	1	4,472.0		223.6	1	4,472.0		223.6	1	4,472.0		223.6
Mooring chain	38φ25m	582	8					1.0	582.0		72.8	1.2	698.4		87.3	1.5	873.0		109.1	2	1,164.0		145.5	2.5	1,455.0		181.9
Bridle chain	32φ14m	303	8					1.0	303.0		37.9	1	303.0		37.9	1	303.0		37.9	1	303.0		37.9	1	303.0		37.9
Swivel	38φ	65	6					1.0	65.0		10.8	1	65.0		10.8	1	65.0		10.8	1	65.0		10.8	1	65.0		10.8
Shackle	38φ	54	6					5.0	270.0		45.0	6	324.0		54.0	6	324.0		54.0	6	324.0		54.0	6	324.0		54.0
Shinker	RC6t	257	25					1.0	257.0		10.3	1	257.0		10.3	1	257.0		10.3	1	257.0		10.3	1	257.0		10.3
Installation cost	Construction	1,300	2					1.0		1300	650.0	1		1,300	650.0	1		1300	650.0	1		1300	650.0	1		1300	650.0
Initial Capital cos	Buoy Depot	700	2					1.0		700	350.0	1		700	350.0	1		700	350.0	1		700	350.0	1		700	350.0
Total									5,949	2,000	1,400		6,119	2,000	1,424		6,294	2,000	1,446		6,585	2,000	1,482		6,876	2,000	1,518

3 L-3 type Lighted buoy

Item	Standard	Unit price	Service life	Depth 10 m				Depth 15 m				Depth 20 m				Depth 25 m				Depth 30 m				Depth 35 m			
				No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost	No. in service	Capital cost	Replace cost	Annual cost
Buoy Hull	L-3	5,817	20					1.0	5,817.0		290.9	1	5,817.0		290.9	1	5,817.0		290.9	1	5,817.0		290.9	1	5,817.0		290.9
Mooring chain	38φ25m	582	8					1.0	582.0		72.8	1.2	698.4		87.3	1.5	873.0		109.1	2	1,164.0		145.5	2.5	1,455.0		181.9
Bridle chain	32φ14m	303	8					1.0	303.0		37.9	1	303.0		37.9	1	303.0		37.9	1	303.0		37.9	1	303.0		37.9
Swivel	38φ	65	6					1.0	65.0		10.8	1	65.0		10.8	1	65.0		10.8	1	65.0		10.8	1	65.0		10.8
Shackle	38φ	54	6					5.0	270.0		45.0	6	324.0		54.0	6	324.0		54.0	6	324.0		54.0	6	324.0		54.0
Shinker	RC8t	348	25					1.0	348.0		13.9	1	348.0		13.9	1	348.0		13.9	1	348.0		13.9	1	348.0		13.9
Installation cost	Construction	1,400	2					1.0		1400	700.0	1		1,400	700.0	1		1400	700.0	1		1400	700.0	1		1400	700.0
Initial Capital cos	Buoy Depot	800	2					1.0		800	400.0	1		800	400.0	1		800	400.0	1		800	400.0	1		800	400.0
Total									7,385	2,200	1,571		7,555	2,200	1,595		7,730	2,200	1,617		8,021	2,200	1,653		8,312	2,200	1,689

Table 3 Resilient Light beacon types R-1, R-2 & R-3

1 Resilient Light Beacon R-1 type

Item	Reference	Basic unit price	Service life	Depth 10m			Depth 15m			Depth 20m			Depth 25m		
				Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost
Buoy 450φ		12,000	20	0.80	9,600.0	480.0	0.90	10,800	540.0	1.00	12,000	600.0	1.10	13,200	660.0
Weight		1,500	25	0.80	1,200.0	48.0	0.90	1,350	54.0	1.00	1,500	60.0	1.10	1,650	66.0
Installation cost	Construction	3,500	20	0.80	2,800.0	140.0	0.90	3,150	157.5	1.00	3,500	175.0	1.10	3,850	192.5
Under water inspect	Measurement, etc.	400	5	0.80		64.0	0.90		72.0	1.00		80.0	1.15		92.0
Repair	Touch up	800	10	1.00		80.0	1.00		80.0	1.00		80.0	1.00		80.0
Total					13,600	812		15,300	904		17,000	995		18,700	1,091

2 Resilient Light Beacon R-2 type

Item	Reference	Basic unit price	Service life	Depth 10m			Depth 15m			Depth 20m			Depth 25m			Depth 30m		
				Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost
Buoy 600φ		14,000	20				0.80	11,200	560.0	0.90	12,600	630.0	1.00	14,000	700.0	1.10	15,400	770.0
Sinker		1,750	25				0.80	1,400	56.0	0.90	1,575	63.0	1.00	1,750	70.0	1.10	1,925	77.0
Installation cost	Construction	4,000	20				0.80	3,200	160.0	0.90	3,600	180.0	1.00	4,000	200.0	1.10	4,400	220.0
Under water inspect	Measurement, etc.	400	5				1.00		80.0	1.00		80.0	1.15		92.0	1.30		104.0
Repair	Touch up	1,000	10				1.00		100.0	1.00		100.0	1.00		100.0	1.00		100.0
Total								15,800	956		17,775	1,053		19,750	1,162		21,725	1,271

3 Resilient Light Beacon R-3 type

Item	Reference	Basic unit price	Service life	Depth 10m			Depth 15m			Depth 20m			Depth 25m			Depth 30m			Depth 35m		
				Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost	Factor	Capital cost	Annual cost
Buoy 800φ		16,000	20							0.80	12,800	640.0	0.90	14,400	720.0	1.00	16,000	800.0	1.10	17,600	880.0
Sinker		2,000	25							0.80	1,600	64.0	0.90	1,800	72.0	1.00	2,000	80.0	1.10	2,200	88.0
Installation cost	Construction	4,500	20							0.80	3,600	180.0	0.90	4,050	202.5	1.00	4,500	225.0	1.10	4,950	247.5
Under water inspect	Measurement, etc.	400	5							1.00		80.0	1.15		92.0	1.30		104.0	1.45		116.0
Repair	Touch up	1,200	10							1.00		120.0	1.00		120.0	1.00		120.0	1.00		120.0
Total											18,000	1,084		20,250	1,207		22,500	1,329		24,750	1,452

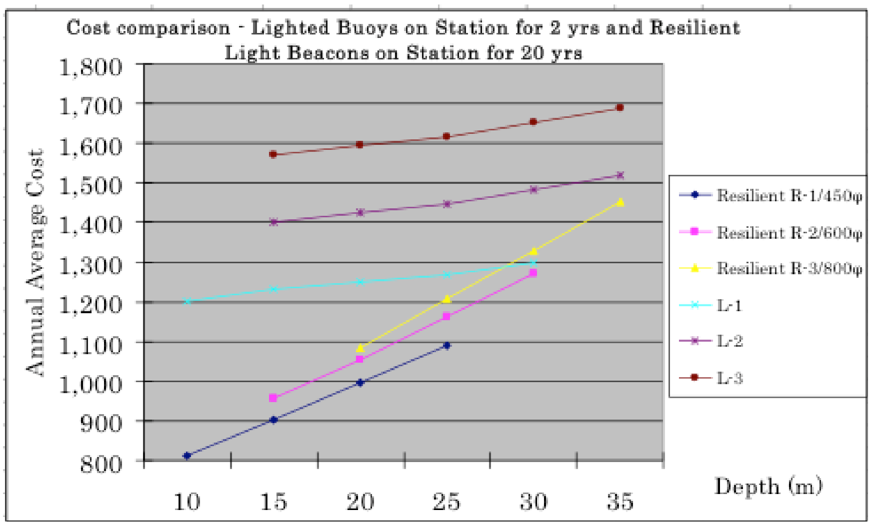

Figure 2 Cost comparison between Lighted Buoys and Resilient Lighted Beacons

Table 4 Total cost comparison (annual average) between Lighted Buoy and Resilient Lighted Beacon

Type	Depth (m)					
	10	15	20	25	30	35
R-1	812	904	995	1,091		
R-2		956	1,053	1,162	1,271	
R-3			1,084	1,207	1,329	1,452
L-1	1,201	1,231	1,249	1,268	1,298	
L-2		1,400	1,424	1,446	1,482	1,518
L-3		1,571	1,595	1,617	1,653	1,689

6. DEFINITIONS

The definitions of terms used in this Guideline can be found in the *International Dictionary of Marine Aids to Navigation* (IALA Dictionary) at http://www.iala-aism.org/wiki/dictionary and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

7. ABBREVIATIONS

AMSA	Australian Maritime Safety Authority
AtoN	Marine Aid(s) to Navigation
GRP	Glass reinforced plastic (fibreglass)
JCG	Japan Coast Guard
m	metre(s)
NPV	Net present value
nm	nanometres
UV	Ultraviolet (light) (10 – 380 nm)