

Building Bird Strike Minimization: Analysis of Applicable Technologies

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Introduction:

While the incidence of strike related mortality between birds and windows is well documented there has been a limited amount of attention placed upon prevention. The purpose of this review is to analyze the many strategies related to bird exclusion and strike minimization utilized in a variety of disciplines to determine those best suited for architectural applications. Furthermore, the research required to effectively deploy a given strategy is discussed.

In the creation of this analysis it became apparent the bulk of bird control knowledge and research does not reside within the realm of conservation and ecology. The aviation industry in particular has engaged in a great deal of research focused on minimizing bird strikes at airports where the safety and financial repercussions can be severe. Although many of the techniques found at airports are difficult to translate to a suburban setting (propane canons, flares, active shooting, etc.) there are a number of techniques that appear to be applicable. Bird control within an industrial and agricultural context is also well researched and developed, but like aviation related methods, relevant techniques have largely gone unnoticed and unapplied within the realm of architecture.

Discussion:

Bird control measures related to strike minimization come in two basic forms: exclusion from the strike site and modification of glass surface to either avoid strikes or prevent the damaging effects. Following this fundamental split there are a multitude of specific strategies, although much less within the realm of glass surface modification. The research conducted indicates that a single solution to bird strikes does not exist. Every building is different as is the ecological and social context in which it is situated. As a result the most effective management technique must be determined on a case by case basis. However it should be remembered by any practitioner that they are operating in an emerging field. While the efficacies of the techniques in this report are noted, there will be a degree of variability in the field and adaptive management will be required. Furthermore all reports indicated that success was greatly improved by layering complimentary techniques, as opposed to relying upon a single solution. To better analyze the techniques and determine which ones are applicable in a given situation a comparison matrix, found at the end of the report, has been developed.

Exclusion Techniques:

The exclusion techniques discussed below operate on the assumption that fewer birds in the area of concern will result in fewer window strikes. While this is undoubtedly true, it does of course negate the site as potential avian habitat. Such efforts may undermine the original intent of environmental attractant such as green roofs and landscaping, but the building designer or manager will have to determine for themselves what constitutes an appropriate compromise.

Sounds:

The use of sound for bird control has been well researched, with the categories of analysis falling into two distinct realms: ultrasonic and infrasonic devices and alarm calls. Although the use of extremely loud sounds is also well documented (propane canyons), there is essentially no applicability to building settings and thus not analyzed in this review.

Ultrasonic and infrasonic devices: A number of products have been developed to remove birds from a given area by utilizing sounds above 20,000 Hz, also known as ultrasonic, and the sounds below 20 Hz, referred to as infrasonic. However the applicability of ultrasonic technology is highly dubious as the limit of most birds species hearing is close to that of humans, topping out at approximately 20,000 Hz. This has two implications: First the sounds that would be a source of annoyance to birds would similarly affect humans. Secondly devices that produce sounds outside the range of humans have no effect. Infrasonic devices have similarly failed to create a consistent repelling response in birds. These conclusions regarding infra and ultrasonic sounds, and there general lack of effectiveness, has been borne out repeatedly in the research, with numerous instances of roosting nuisance birds being entirely unaffected by exposure.

Alarm calls: The effect of alarm or distress calls on avian behavior has been well researched resulting in conclusive understandings of their impact. Distress calls emitted by bird species are intended not as a warning to other species, but rather as a means to startle a predator into releasing them. The resulting behavior of other birds upon hearing a distress sound is first investigation of the source and then a vacating of the area. This has several impacts on the effectiveness of utilizing playbacks of distress calls as a means of reducing bird presence. The use of distress signals as a sound only deterrent is of limited to no utility. Without the visual signal of a predator holding a captured prey to corroborate the sound, distress calls have been shown to have no effect. However when coupled with a predator species holding a victim of the sort emitting the distress call results in a brief investigation by area birds followed by a rapid evacuation. However even this response can be subject to habituation given regular exposure, thus the temporary or irregular use of distress calls is necessary. Furthermore the nature of such distress sounds and the necessary volume may create a disturbing human environment. This potential human impact has been not explored in the literature.

Necessary research for successful implementation:

Utilization of matching predator and prey models and distress call are all necessary for maximum efficacy. While this serves as a testament to the capacity of birds to accurately identify and respond to a real risk, it also serves to stress the importance of identifying the birds to be excluded so as to determine the appropriate prey and predator sounds and models.

Sources: (4, 6, 8, 12, 16, 18, 21, 28, 38)

Models:

The models are a common deterrent method and often found in home and garden catalogs. Most models sold are predator models, although within the realm of more industrial bird control there has been the utilizing of target species carcasses, either models or real, as deterrents. The research indicates such models can be highly effective, but only if they have certain features and characteristics to maximize their lifelike nature, otherwise they have been shown to have no utility. Additionally the effectiveness may be variable depending upon species as it was found larger birds alter habitat preferences in response to predators while small birds are often unaffected.

Predator Models: The effectiveness of a predator model depends upon making it appear as realistic as possible. This is evidenced by experiments where the use of low quality models has had no effect while those utilizing highly realistic models have reduced species presence by over 80%. As a component of realism, movement should be considered essential when using predator models. The nature of this movement is not as important, with wind born rocking, or electric animatronics all being effective. A second component for the effectiveness is the grasping of prey by the model, which similarly should be animated. In some instances live, tethered birds have been used with great success, which demonstrates the need for realistic models. The furthering of model predators effectiveness can be accomplished through the use of distress call playbacks from the “captured” prey. Additionally the regular relocation of the predator models around the target area can delay the onset of habituation.

Carcass Models: Although admittedly a bit unseemly, the use of models appearing to be dead birds or even dead birds themselves have been found to reduce target species presence within a given area. As a deterrent such models are often investigated prior to birds vacating the area, which may reduce overall presence, but does not prevent initial visits. The time to habituation has been shown to be variable relative to different species and realism, with the effectiveness extending up from a few days to several months before habituation.

Necessary research for successful implementation: With all models it is important to make them as realistic as possible to extend the time until habituation. Thus research into the precise species to be excluded and the appropriate predator should be noted and incorporated into the models.

Sources: (6, 14, 15, 18, 20, 21, 28)

Hazing and Falconry:

Clearly if models of predators are noted for effectiveness, then the use of actual predators should be even more effective. The use of falcons as means of controlling bird populations receives quite a bit of positive press, leading to a perception of more widespread adoption than may actually be the case. As a technique it has proven to be very successful, especially in large areas and in conjunction with secondary techniques such as propane canons. The applicability of falcons to smaller scale applications is more limited as it requires a regular presence, meaning multiple falcons and a full time handler. In an airport setting this can make sense, however on the building scale the argument is less persuasive. However as a testament to the efficacy of falcons, it has been reported that within a limited time the approach of the falconer's truck becomes as strong of a deterrent as the falcons themselves.

Sources: (7, 21)

Habitat:

The most advocated technique for large scale bird control is the manipulation of habitat to make it less desirable for the target species. This has the effect of reducing overall presence and increasing the effectiveness of other techniques, such as predator models, as there is now less incentive for entering the area. The most notable benefit of habitat alteration measures is the lack of habituation. The effect of an altered habitat is constant and thus bird species do not adapt to the changes but rather seek out more appropriate alternative areas. The alteration of habitat comes in several forms, listed below:

Flora: Analysis at urban gardens and other created habitat indicates the small patch flora composition can have a very strong influence on species presence. In particular it found a positive correlation between passerine species and percent cover of shrub species. There is little correlation between native and non-native flora with regards to bird presence, indicating that bird presence can not be manipulated by the simple choice of non-native species. As the species composition can be tailored to maximize bird presence, it follows the inverse must be true, which would require a cataloging of bird species in the area and an elimination of the flora to which they have an affinity.

Food and Water: Food and water are very strong draws for bird species and thus their elimination at the target area can dramatically reduce presence. Their elimination can also increase the effectiveness of secondary control measure as there would be a reduced incentive to undergo any risk if the reward of food or water were removed. Additionally the provision of food or water in another nearby location, coupled with removal in the target area, has been shown to effectively lure species away from the target site.

Management: The flora management practices on a given site have been utilized in airport situations as an effective means of species control. In that application grasses and shrubs around airfields were maintained to a taller height which larger species of birds, those most damaging in aircraft collisions, would not inhabit. Rather such tall grasses and shrubs are preferred by smaller passerine species, a conclusion corroborated by the

analysis of urban gardens. Thus it can be concluded that the management of an area to reduce grass and shrub height would discourage the presence of small bird species.

Necessary research for successful implementation: A cataloging of the bird species present on the site and their habitat preferences would be required. Identification of attractant flora species and associated management would also have to be determined. Food and water sources on the site would have to be located and appropriate locations for the new “lure” would be needed.

Sources: (7, 8, 18, 21, 34, 37)

Timing:

Timing, on multiple scales, is evidenced in the patterning of bird strikes. Both on a diurnal and seasonal cycle the pattern of bird movement can be predicted. While timing in of itself is not a solution to the issue of bird strikes, it provides an important understanding of behavior. This information should be used to determine when strikes are likely to occur and as a result when efforts at strike reduction need to be maximized with the additional layering of techniques.

Diurnal: It has been found that the weight of passerine bird species can fluctuate by up to 7% from dawn to dusk. The heavier weight at dusk, resulting from daytime feeding, decreases lift and flight velocity by as much as 30%, dramatically reducing capacity to avoid predators. The result is reduced levels of movement at the end of the day, culminating in very little movement at night. This pattern is corroborated with the majority of strikes, when recorded, occurring during the early and late morning, when the birds, lightened by thermogenic processes at night, begin to forage. In particular the morning strikes occur when migrating birds that have rested for the night in vegetation near the target site begin to forage upon waking up the next day. All sites are variable and should be analyzed to determine the presence of this pattern; however overall it should remain constant. The implications are that targeted measure to reduce strikes can be implemented during the morning hours will reduce the majority of potential strikes.

Seasonal: Although the analysis of some research has indicated a lack of seasonal patterning for bird strikes, the overwhelming bulk of the research indicates that strikes occur during the fall and spring, correlating with migration patterns. Research has indicated that on the smaller building scale these strikes occur when birds have rested for the night in vegetation near the target site and then begin to forage in the morning. This is not to say strikes do not occur during other seasons, however the number are vastly reduced, and typically resulting from an off season local attractant, such as bird feeders. The implication of this pattern is that extra effort, and redundant systems, should be implemented during these times of year. This has the benefit of reducing the required effort on the part of building managers and lessening the potential of habituation that would otherwise occur if certain measures such as models were utilized throughout the year.

Necessary research for successful implementation: Although the overall observations of bird strikes indicate the weight of the aforementioned patterns, there is still a degree of

site variability. Thus an ongoing analysis of bird strikes, either through “thump” sensors or body collection should occur to determine the extent of strikes duration both on a daily and seasonal basis. The vegetation utilized as the night roosting spot should also be noted so as to apply habitat modification efforts.

Sources: (10, 13, 19, 26, 30, 36)

Light:

The use of light and birds perception of light has the potential for reducing building bird strikes. The applicability of light assumes multiple forms, with those relevant to the building scale and related to exclusion outlined below.

Night lighting: It has been found that the use of lights at night in high rise buildings can significantly increase the likelihood of nighttime migratory fatalities. Light apparently causes disorientation and attracts birds to structures, resulting in impact and death. A side by side comparison of strike frequency for the same structure, lit and unlit, has demonstrated the dramatic affect of nighttime lighting. Should analysis indicate that night strikes are an issue, turning off all building lights is necessary first step.

Lasers: Lasers have been shown to be highly effective against most, but not all species of birds. The basic operation is the training of a laser emitter on a target bird, with the result being the species leaving the site. Some species are highly responsive to the application of lasers, while others have little or no response. This variation in sensitivity requires that species targeted and receptivity to laser light wavelengths to be known. The use of lasers also requires an operator to regularly disperse the birds, adding significantly to the cost. Currently there is no indication that species habituate to lasers, indicating they could be a suitable technology for areas where bird presence is particularly problematic.

Necessary research for successful implementation: The time of day for strikes is particularly important in determining if turning off lights at night is an appropriate response. Species can be the decider for the use of laser technology, as well as the severity of the problem, which could serve to justify the cost of an operator.

Sources: (2, 3, 18, 21, 27, 32, 33, 35, 36)

Chemical inhibitors

The use of non harming chemicals to control bird presence has been used with success on a variety of bird species. The products are primarily taste inhibitors, essentially blanketing the area with a foul tasting substance, thus affecting any of the available forage. There is no indication in research or practice that birds habituate to chemicals. There are two types of appropriate, non harming chemicals for bird control applications:

Anthraquinone: A chemical substance marketed under the name Flight Control, anthraquinone has proven to be highly effective at reducing bird presence in a given area. The substance works on two levels, first as a visual irritant as it is visible within the UV spectrum only, which birds can perceive, and as a taste irritant. When birds eat food

treated with anthraquinone they have a strong negative, but non-harming, response that drives them into other untreated areas. Secondly they appear to develop an association between the UV coloration and the foul taste, which covers the feet and feathers when they enter a treated area, which they ingest upon preening to remove the UV spots. There is no reported toxicity of the substance although as a polycyclic aromatic hydrocarbon there are questions about its effect on certain species, particularly aquatic life, although it has been approved as non-toxic by the EPA. The re-application time for this substance is extensive at over one month, allowing use coverage peak migration seasons to require two or three applications. This chemical, when utilized with other inhibitors could prove highly effective at reducing bird strikes.

Methyl-anthranilate: On the market longer than anthraquinone, methyl-anthranilate is sold under the name ReJex-it. This product is also listed as EPA non-toxic and numerous studies, related to aquaculture applications, have documented no ill effects on mass or behavior when included in fish diets. The chemical works by creating a strong taste when eaten, driving birds to seek other areas. The interval length between applications is half that of anthraquinone and it does not have the UV visible component, which may reduce effectiveness. However the product can be distributed as a fog over the target area at regular intervals which has shown to have good effect at reducing bird presence in a given area with minimal repetition required. Some sources have noted there is associated grapelike odor although information to corroborate that, beyond the competitors website which sells anthraquinone, has not been found.

Necessary research for successful implementation: Determine if the birds striking the building are occupying and feeding in the area as the application of chemicals will only be of utility if they are. Determine if there is a strong attractant in the region which may cause the inhibiting effects of the chemicals to be overpowered. Determine if the use of the chemicals is possible given the local laws and regulations.

Sources: (2, 5, 9, 17, 18, 21, 29, 35)

Overhead wires

Overhead wires are an older technology that has been appropriated from agricultural bird control applications to other venues, primarily aquiculture sites and landfills. The system is based upon the discovery that wires strung up above the target area greatly reduce or entirely eliminate the number of birds found on the target site. This technique has been shown to be effective on a variety of species although the effectiveness in reducing the presence of all small songbirds has not been comprehensively explored. In instances where starlings and sparrows were studied, lines 30 to 60 cm apart were used effectively. For larger species such as gulls lines as far apart as 1 meter have proven effective. The lines do not have to be visible in order to have an affect and studies have implemented line networks effectively as high as 80 feet. The effectiveness has been shown to increase further when used in conjunction with other management techniques, particularly predator models. The reason for improvement is speculated to be birds' response to the impaired capacity to rapidly escape from the area due to the wires. The presence of a predator builds on this fear, improving function. Despite demonstrations of

notable effectiveness in both scientific research and real world applications, this technology has not been implemented in an architectural setting. However it should be noted that species have varying requirements as far as line spacing and the lack of widespread implementation would mean any application could qualify as an experiment.

Necessary research for successful implementation: The application of wires would be an experiment in adaptive management. The stringing of line at the spacing utilized in the starling experiment, 30 cm, would have to be monitored and adjusted as necessary. Area attractants would have to be noted and relocated or minimized to reduce incentive. Determination of appropriate predator models to further increase effectiveness would also be a needed research subject.

Sources: (13, 25, 27)

Surface Modification:

The techniques listed under this category are significantly fewer in number than the exclusionary measures. Relatively little research has been conducted however the results that have been produced indicate there are very effective measures that can be taken to eliminate fatal strikes by altering building facades.

Glass Patterning

The use of patterning is essentially an effort to make what is otherwise invisible to birds visible. The technique requires the orientation of an opaque pattern on glass in horizontal or vertical rows to create a visible surface. As the goal is the creation of a visible surface, a large quantity of the pattern is required. Research indicates that patterns separated by no more than five to ten cm for the horizontal and vertical respectively, is required to serve as an effective deterrent. The nature of the pattern is irrelevant, negating the effectiveness of such features as hawk silhouettes and “glowing eyes” unless they are placed in the appropriate density. The efforts utilized to make glass thus visible have involved the adhesion of stickers and fritting, a practice implemented at Swarthmore College.

Sources: (12, 19, 20, 21)

Glass Angling

Research into the affects of angling glass to alter the nature of the reflection has been shown to be highly effective at eliminating bird strikes. Angling glass more than 20 degrees virtually eliminates all strikes on ground story windows as the reflected surface becomes the ground; a barrier birds recognize. However this becomes increasingly difficult with building height and may be limited in its applicability to lower story windows only. Secondly window angling would likely be prohibitively difficult and expensive as a modification after a building has been constructed.

Sources: (21)

Physical Barriers

The concept behind the use of physical barriers is to create a softer impact site when birds do strike windows. There has been no experimentation with the efficacy of such a product and it seems there may be only a limited number currently on the market

(birdscreen.com). The effectiveness is dependent upon the medium used being small enough to prevent the passage of a bird and appropriately tensioned or positioned to prevent a bird's momentum from resulting in a fatal impact despite the net. The existence of bird traps dependent upon a loose net with horizontal pockets which stop the bird and then catch in the pocket for retrieval is a testament to the potential effectiveness of such a system despite. Utilized in conjunction with annual and daily strike data, the targeted deployment of such a screen can be limited while not unduly undermining effectiveness. However as a solution it would, at this point, likely require a degree of custom fabrication, particularly when applied to larger buildings.

Necessary research prior to implementation: Determine the location where bird strikes are occurring to provide a least cost targeted response. A noting of time of year or day of bird strikes may indicate that the use of barriers is only required during limited times or seasons.

Source: (21)

Light

While light has been successfully used as a means of exclusion, there has been limited research into the capacity of light raise bird awareness windows.

Strobes: Strobe lights, when compared to steady state lights, are effective in preventing nighttime bird strikes. Particularly in taller buildings, where lighting may be required by the FAA, the use of strobe lights can dramatically decrease birds' attraction to the structure. This is not to imply that such light serve as a deterrent, rather if exterior lights have to be used; pulsing ones are preferable to steady burn lights.

Ultra violet: It has been well documented that the UV range is visible to birds. Experiments thus far have been focused on training birds to discern the difference between UV and non-UV treated surfaces that are otherwise visually similar. Such training has proven effective however the utilizing of this capacity to minimize bird strikes is just now undergoing experimentation. While there is no published data on the effectiveness of UV reflecting glass for minimizing bird strikes, research indicates the use of the chemical Anthriquinone, which is UV reflective, to be highly effective at reducing bird presence. However Anthriquinone also has a severe taste component that may exclusively responsible for its effectiveness. Anthriquinone can be easily applied to surfaces as a paint like substance and experimentation to increase the UV visibility of a building would be relatively easy to engage by coating the glass surfaces. It is not certain what discoloration might occur from using anthriquinone in this capacity, but the substance, in the commercial form Flight Control, is colorless when applied to vegetation. There may also be other, more appropriate UV coatings available.

Necessary research prior to implementation: If steady burn warning lights are used, relevant regulation should be reviewed to determine if switching to strobes is possible. The lack of knowledge on the use of UV coating to prevent bird strikes means implementation could be considered a much needed experiment.

Sources: (2, 18, 21, 24, 35)

Conclusion:

Addressing the issue of building bird strikes is in the nascent stages of development and only now becoming a widespread issue of public concern. Little implementation has occurred in the field and the results from what has been done has not been effectively shared with the greater community of builders and architects. The techniques outlined in this analysis serve as a jumping off point; an inventory of the proven methods available for appropriation. Choosing and implementing a technique should be considered an exercise in adaptive management and one in which the lessons learned need to be communicated to the larger field of architecture professional. While there is no shortage of possible remedies, the process of technique selection and application will require a high degree of creativity and awareness and for those early practitioners this analysis will ideally serve as the beginning what will develop into a more universal and codified component of the building façade design vocabulary.

Analysis Matrix of Bird Strike Management Techniques:

Technique	Effectiveness	Public acceptance	Cost	Concurrent measures	Notes
Ultrasonic and Infrasonic sound	None: Not recommended	-----	-----	-----	-----
Distress and Alarm Calls	High: Must use with models	Med: The calls may be disturbing	Low	Realistic models with captured prey	Rapid habituation will occur unless accompanied by a predator model with captured prey.
Predator Model	High: Must be realistic	High: People are already familiar with the concept	Low - Med	More realistic the better. Must include movement	Habituation is related to model realism. Captured prey, distress calls, and movement are all important. Relocation will also increase effectiveness
Carcass Model	High: Must be realistic, might be species dependent	Med –low: Non-harming but can be disturbing	Low-Med	None noted as essential although a predator model could be effective	Highly realistic carcass models found very effective for deterring Gulls, unknown effectiveness for other species
Falconry	High: But not recommend	High	High	High volume sounds such as propane canons	Popular but expensive measure, not appropriate on the building scale.
Habitat Modification: Flora	Med-High	Low-High: depends on nature of required alteration, i.e. tree removal or shrub removal	Low-Med	Other forms of habitat modification and other exclusion methods	Considered cornerstone of any effort. Reduces species preference for the site. Can add to effectiveness of other measure by reducing incentive.
Habitat Modification: Food and Water	Med-High	Med-High	Low-Med	Other forms of habitat modification	Considered cornerstone of any effort. Water and food are often anthropogenic in

				and other exclusion methods	source in urban environments. Provision of lure food in another area is also effective.
Technique	Effectiveness	Public acceptance	Cost	Concurrent measures	Notes
Habitat Modification: Management	Med-High	High-Med	Med-Low	Other forms of habitat modification and other exclusion methods	The alteration of management efforts may be difficult with some grounds crews. Could require retraining or careful explaining of required practices.
Timing: Diurnal Cycles	High: Not a strategy in itself but a consideration for all other responses	-----	-----	Should be considered when deploying any strategy	Can be very important when targeting response. Most patterns indicate an increase in morning activity relating to foraging.
Timing: Seasonal Cycles	High: Not a strategy in itself but a consideration for all other responses	-----	-----	Should be considered when deploying any strategy	Can be very important when targeting response. Can dramatically reduce cost by justify efforts only during peak season. Building monitoring should be engaged to determine accuracy.
Night Lighting	High	Med	Low	Should be deployed if strikes occur at night	Easy no-cost measure if there are any night strikes
Lasers	High	High	Med-High	Should be deployed for targeting nuisance birds not deterred by other efforts	Requires an operator but has proven effective at removing nuisance birds. Cost of operator may be prohibitive.
Anthraquinone	High	Med: Use of chemicals is always problematic	Med	Will increase the effectiveness of any habitat exclusion technique	UV qualities and long duration of anthraquinone make it a very attractive option. Could greatly reduce the incentive of birds to occupy an area.
Methyl-anthranilate	High	Med: Use of chemicals is always problematic	Med	Will increase the effectiveness of any habitat exclusion technique	Although not as long lasting and lacking the UV component of anthraquinone, it can be distributed as a fog in a given area, allowing exposure for birds that fly through the area.
Overhead Wires	High-Low: High variability in species	High: People will likely not see the wires	Med-Low	Best accompanied by predator models	The results from wires indicate that it can range from highly effective to ineffective. A partial list of

	response				species susceptibility is found in <u>Kessler et al. 1991</u>
Technique	Effectiveness	Public acceptance	Cost	Concurrent measures	Notes
Glass Patterning	High	Low-High: Can't see through but efforts are readily evident	High –Med high	None required	Requires extensive covering to be effective, difficult to accomplish retroactively in an aesthetic and cost effective manner
Glass Angling	High –Low: Depends on window height	Med: Not a common architectural feature	Low	None required	May only be effective on lower story windows. Difficult to apply as a retrofit.
Physical Barrier	High	Med: Can disrupt aesthetics from exterior	Med-High	None required	Limited manufactures and has not been applied on a large scale. Creates little visual disruption from the inside. Could be linked to automated deployment system during peak hours and seasons.
UV light	Unknown	High: Not visible to humans	-----	None required	Limited research on effectiveness of UV light and window avoidance. Any application would represent an experiment, but an important one.
Strobe light	Med-Low: Not a significant deterrent but not an attractant like non-flashing lights	High-Low: Depends on area of deployment, could be major annoyance	Low	Best options is no exterior lights, otherwise flashing lights are better than steady burn lights	Has been shown to moderately deter bird presence, but primarily recommended in situations where exterior warning lights are required

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