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Illuminating the Invisible Sky

A Strategy for Obstacle Lighting Visibility

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Executive Summary

The high reliability and low operating cost of light emitting diodes (LEDs) has fueled their use by airports and other national airspace system (NAS) stakeholders for a variety of lighting purposes, illuminating everything from runway edges to obstructions. However, a significant amount of LED-based lighting emits exclusively on wavelengths that are filtered by night vision goggles (NVGs). As a result, these lights are partially or completely invisible to pilots operating with NVGs. While this has implications for all airport lighting, obstruction lights are of primary concern as they are critical to the safety of low-level navigation.

The technology required to solve this problem is already mature and commercially available. The challenge is not in changing the lights, but rather making all of the LED obstructions lighting in the NAS compatible with NVGs. Consequently, the following proposal describes the Strategy for Obstruction Lighting Visibility (SOLV), a roadmap to help airport operators improve the safety in the operating environment surrounding their airports. The proposed plan includes three phases: establishing a technical standard, amending the regulatory framework, and prioritizing conversion. SOLV aims to provide a key safety improvement to operators by resolving the existing incompatibility between NVGs and LED lighting.

This proposal was developed through a series of diverse activities such as industry and subject matter expert interviews, an on-site visit, building an LED display to witness the problem first-hand and creating a “proof of concept” obstacle map to help refine our plan.

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1. Problem Statement and Background

While humans have developed excellent day vision, they have not evolved equally high-quality visual capabilities for low-light conditions. Technologies to enhance vision in low-light conditions, such as night vision goggles (NVGs), have allowed pilots to conduct operations in poor lighting conditions that are normally considered extremely dangerous and hazardous. NVGs allow pilots to operate in inadequate or poor lighting situations, a common characteristic of night operations, search and rescue operations, law enforcement operations (police, border control, surveillance, etc.), and wildlife observation.

At night, light is not as well perceived by humans as daylight. However, several natural sources of illumination are present, including residual sunlight, moonlight, and starlight. In cloudy conditions, light sources found in urban areas can create more light through reflection off of the clouds. While most of the light emitted during nighttime conditions cannot be perceived by the human eye, as it is at the edge of or beyond the visible range, night vision-enhancing technology is able to use that light to increase human ability to see at night and during poor or low lighting conditions. The basic operating principle of NVGs involves receiving and intensifying the available light and then displaying that available light-image to the human eye (e.g. Parush, Gauthier, Arseneau, & Tang, 2011).

Three generations of NVG technology are recognized and discussed in a review by Parush, et al. (2011). The first generation of NVGs, which appeared in the mid-1960s (i.e., the Vietnam War era), used image intensifier (I^2) technology, and was primarily used by infantry. These NVGs primarily relied on moonlight and starlight, resulting in very poor resolution. This generation was characterized as ineffective during cloudy conditions and moonless nights. Major improvements to the first-generation I^2, such as higher gain and better image resolution, resolved those issues and allowed users to see during those extremely low-light conditions. These improvements, along with better image resolution, evolved into the second generation of NVGs. Increased spectral sensitivity characterized the third generation. Furthermore, the third generation of NVGs is sensitive to light in the range of 550 to 950 nanometers (nm). This represented an improvement over the second generation, which only covered a range of 400 to 900 nm and tended to be less sensitive near the infrared (IR) range. This improvement in the third generation technology allows users to perceive more details with better contrast against the environment in very low light levels.

Depending on the available light from the moon and the surroundings (lights coming from an urban environment), NVG pilots will use aided vision for takeoffs, landings, and navigation. When operating under NVG conditions during en-route navigation, it is left to the pilot's discretion whether or not to use aided vision for takeoffs and landings. However, in most cases, pilots choose to transition from aided to unaided vision for those phases of flight, due to sufficient ambient lighting.

Regulations pertaining to NVGs and their operation can be found in the Federal Aviation Regulations (FAR) Parts 61 and 91. These regulations present civil NVG users with a foundation for the development of NVG training programs, operating procedures, and instructor minimum standards. NVGs must be approved for operation by the Federal Aviation Administration (FAA), however, "90% or more of the NVGs utilized in FAA regulated flight operations are [currently] not FAA approved," according to Rowles (2012, p. 32). In addition, the only NVGs to be FAA Technical Standard Order C164 (TSO-C164) approved are Nivisys Night Vision Aviator Goggles (NVAG). Two other models, ITT F4949 and L3 M949 NVGs, are FAA accepted, not FAA approved, for use.

Up until recently, the use of Light Emitting Diodes (LEDs) in the aviation industry was very limited. Once their advantages and benefits became known, the number of uses for LEDs in aviation started increasing. Indeed, it seems that the growth in LED use can be attributed to their "virtually indestructible" and energy efficient nature. LEDs are not susceptible to shattered glass or broken filaments, they operate at a cooler temperature than incandescent lights, and their service life has been found to be up to 100,000 hours (Escobar, 2005). The use of LEDs is becoming more common for almost all airport lighting applications (runway, taxiway, and obstruction) contributing to the problem addressed by our team.

Although the aviation community has embraced LEDs, using them as runway, obstruction and navigation lights, a certain group in the aviation community appears to have been neglected during the transition. NVG operators, including law enforcement, emergency medical services and search and rescue personnel, and other NVG operators, are left facing NVG incompatibility problems. Specifically, many LEDs are not compatible with NVG operations. The issue lies in LEDs having a relatively narrow range of light and being unable to emit infrared energy like incandescent lights. While some LEDs might be able to meet FAA requirements for Aviation Red, for example, they can emit within a range that falls below the NVG-sensitive range of about 665 to 930nm. These LEDs are then invisible to NVG operators. NVG users are made aware of this incompatibility and warned by the FAA to use extra caution when operating in the vicinity of obstacles. NVG crews are also to report any inadequately marked obstacles to the nearest Flight Standards District Office (FSDO) or the appropriate military Safety Officer.

2. Problem Solving Approach

The problem of incompatibility between LED lighting and NVG operations involves a number of technical, procedural, economic and regulatory aspects. In order to effectively design a solution, the problem space must be sufficiently understood first. Then, after the solution is designed, it must be validated to ensure that it both addresses the problem and is feasible and optimized. Using this cycle of learn, design, and validate, our team developed SOLV, a Strategy for Obstacle Light Visibility.

While the structure of this report may give the impression that we passed through each stage only once, the reality is more complicated. We describe our approach as a cycle because we passed through each step multiple times before arriving at our final design. The use multiple iterations provided several advantages. First, the impact of missing a detail in any of the phases was reduced as the ability to re-visit each step was planned into our schedule. Secondly, our total amount of time and resources were split between all of the iterations, meaning that if one cycle was deemed non-productive, it could be discarded without great impact to the overall project. Furthermore, since each cycle advanced the project as a whole, progress was distributed evenly. This is preferable to a linear problem solving model where excessive time spent in an earlier stage results in less time available for a later one.

An example of this iterative process is how we learned about and understood our problem. When the team was initially formed, we were given no constraints or guidance other than what was found in the FAA competition booklet. Members of the team individually research various airport and airspace issues in search of a topic that was interesting, achievable and leveraged the team's existing skillsets and resources. Once the problem of interest was identifying, learning activities focused on a thorough search and review of existing literature.

Subject matter experts (SMEs) in the domain were contacted at this point, but the conversations were broad, seeking general information vice answering specific questions.

As our design became more mature, learning efforts became more focused on understanding specific details and filling in knowledge gaps. Interviews with industry contacts and SMEs became more structured and dynamic as we solicited opinions about specific issues.

One learning activity worth highlighting was the fabrication of our LED display. During preparations for our trip to an NVG flight school, we realized that we did not have a means to observe NVG-LED incompatibility in a controlled setting. In order to rectify this problem, we engaged the services of an electronics technician. With his assistance, we designed an LED display, procured the components and built it in time for our trip. Had we used a linear problem solving method, it would have been unlikely that we'd have identified the LED display requirement during the learn phase and less likely that we would have had the time to address the requirement whenever it would have been identified.

3. Summary of Literature Review

One of the most important steps contributing to the development of SOLV was the review of current literature to help understand and clarify certain concepts, identify current and future technology, as well as review and understand FAA requirements and regulations. A variety of articles, including peer-reviewed journal articles, and FAA publications were used to guide this effort. These sources can be found listed in Appendix F; three particularly key sources are discussed below.

To begin, the team aimed to better understand the world of NVGs: the users, the equipment, and the operations. One particular piece of literature that was distinctly helpful with this task was a paper by Parush, et al. (2011), titled "The Human Factors of Night Vision

Goggles: Perceptual, Cognitive, and Physical Factors.” Indeed, this paper provided our team with the human factors of NVGs, the basics of the technology, a description of the environmental factors coming into play while operating with NVGs, as well as the practical implications of NVGs. The team then focused on further understanding the issues behind the incompatibility of NVG use and LEDs. As discussed earlier, while LEDs have been widely adopted and implemented as aviation lights, it seems that little consideration has been given to NVG operations and the lack of compatibility with LEDs. The team researched current FAA regulations and requirements concerning the use of NVGs and the implementations of LED use. In this effort, the team reviewed the following Advisory Circulars (AC): AC 70/7460-1K, *Obstruction Marking and Lighting*, and AC 150/5345-43G, *Specification for Obstruction Lighting Equipment.* It became explicitly clear to the team that while some of the technology required to solve this incompatibility problem already existed, a set of regulations for NVG-operating airports was missing.

4. Existing Technology

Our problem can seem fairly easy to solve. Some LEDs, in today’s market, are advertised as NVG-compatible. However, these lights have not yet been approved for such use by the FAA. As mentioned earlier, only a few types of NVGs are approved or accepted for use by the FAA, making it important to ensure that these and future approved models present similar characteristics in filtering light. It is critical to obtain a universal solution to this incompatibility issue, in conjunction with the verification that the NVGs being accepted or approved by the FAA are manufactured to the same standards (light filtering and light capture).

4.1 FAA-approved NVGs

The civil use of NVGs is approved only for the purpose of enhancing operational safety (FAA, 2008). A 1994 FAA study summarizes the beneficial use of NVGs for emergency medical services (EMS) helicopter operations. It states that "when used properly, NVGs can increase safety, enhance situational awareness, and reduce pilot workload and stress that are typically associated with night operations." According to 14 Code of Federal Regulations (CFR) Part 21, NVGs require FAA certification and specific approval. At the time of this report, it appears that only one model of NVGs, Nivisys Night Vision Aviator Goggles (NVAG), is FAA TSO-C164 approved. ITT F4949 and L3 M949 NVGs are FAA-accepted models, but are not FAA-approved.

4.2 NVG-compatible LEDs

NVG-compatible LEDs exist and are available on the market. Produced by Flight Light, Inc., low-intensity NVG-compatible LED obstruction lights, type L-810 (red only), can be purchased directly from the manufacturer. In addition, Flight Light, Inc. commercializes a medium-intensity NVG-compatible LED flashing red obstruction light (FAA L-864) and a medium-intensity NVG-compatible LED flashing red/white obstruction light (Type L-864/L-865). According to the manufacturer, these lights provide pilots using NVGs unmatched visibility of buildings, and towers. In addition, the L810LEDNV light is the first LED L-810 available to ensure that structures are visible to all pilots, "making it the first true LED replacement for incandescent obstruction lights" (Flight Light, Inc., n.a.). Flight Light's NV-series LED obstruction lights combine Red (620nm) and IR (850nm peak intensity) LEDs to ensure that obstructions marked with these beacons and side lights are visible to all pilots, whether viewed aided or unaided. These NVG-LEDs comply with FAA AC 150/5345-43F, *specifications for obstructions lighting*.

5. Trade study

Although the solution is simple, two different approaches can be taken to reach compatibility between NVGs and LEDs. The first one is the tactic chosen by our team: SOLV. Currently used LEDs can be modified to become compatible with NVGs or can be replaced with NVG-compatible LEDs. The second possible approach is to modify NVGs so that the range of light emitted by LEDs is no longer filtered out.

The team decided upon the first approach based on a few factors. Indeed, when researching the topic and the current existing technology, the team realized that while NVG-compatible LEDs already existed and were available, there were no LED-compatible NVGs on the market. As mentioned earlier in this report, NVG-compatible LEDs are being manufactured and are available for purchase. Flight Light, Inc. commercializes FAA approved NVG-compatible LED obstruction lights (FAA L-864 Type L-864/L-865). In addition, Flight Light's L810LEDNV is visible to all pilots, whether viewed aided or unaided. These LEDs are in compliance with FAA AC 150/5345-43F, *specifications for obstructions lighting*.

Replacing current LEDs with NVG-compatible LEDs is a fairly simple task and can be done within a reasonable amount of time. Obstruction lights need to be replaced for maintenance or at the end of their service life, or when their need is no longer required (completed construction or demolition of current obstruction). Therefore, the replacement of the current LEDs is a straight forward step towards implementing NVG-compatible LEDs and can be done as part of normal maintenance measures.

On the other hand, the modification of current NVGs is not as simple. There is currently no NVG model compatible with LEDs. Reaching compatibility from a NVG standpoint would require further research, testing and manufacturing. Indeed, the operational characteristics of NVGs would need to be modified to allow for LEDs to become visible, rather than filtered out. This approach would involve NVG manufacturers and possibly require a significant amount of time before a solution is reached, in comparison with the first approach.

6. Stakeholders

The stakeholders in a system are those individuals that are directly or indirectly investing in and/or gaining from the system. Most systems include a number of stakeholders and our design solution is no exception. This analysis identifies the stakeholders who will be directly involved in the system and those who will be affected by the system.

First, the FAA will need to authorize the implementation of the LED lighting regulations. Because they would offer a technical standard for ground LED lighting, these regulations would deliver the necessary requirements to advance the safety measures for NVG flying that the FAA is striving to provide. A safety risk management analysis has been conducted to give surety to this safety standard and is described in a later section of this report.

The next layer of stakeholders, beneath the FAA, contains the user and operator of NVGs. In the case of Palm Beach Helicopters, those users are the instructors and students of the school. These users will have direct contact with NVGs and participate in NVG flying. To expand upon this, any operators operating using NVG technology will fall into this category. These include: air ambulance, law enforcement, search and rescue, military operators, and flight schools. These users are responsible for operating the aircraft in a safe manner and acquiring the knowledge necessary for operating with NVGs. Their safety is at risk due to the existence of obstructions rendered “invisible” because of incompatible LED lighting. Therefore, proper standards should be set in place and methods developed to ensure the safety of these users by eliminating the possibility for such obstructions.

The owners of companies and businesses that operate, sell, or manufacture NVGs are also stakeholders. If the use of NVGs during flight can be made safer through the development of technical standards for LED lighting, then these stakeholders will reap the benefits of a growing industry. Conversely, if such standards are not set in place, growth in the industry will be difficult to cultivate because of the inherent safety risks. Currently this industry is striving to grow. More and more pilots are being required to obtain NVG training because the numerous jobs demanding the benefits of NVG technology continues to grow.

Another set of stakeholders is the lighting manufacturers. The technology for compatible LED lights regarding NVGs exists in the market place. New technology would not have to be created; however, the production of LED lights will increase. Along with a production increase, an increase in sales may also ensue. The regulations being put in place would indirectly affect the lighting market.

The final group that is categorized as a stakeholder is the obstruction owners. This may include an individual owner or a larger entity such as a corporation or the government. For the purposes of this proposal, an obstruction is defined as anything of a certain height that requires anti-collision lighting. Obstructions encompass a wide variety of structures, from cell phone towers to temporary utility crane to all buildings. Clearly, the owners of obstructions will be directly affected by the new regulations.

The majority of the stakeholders that our team communicated with were NVG operators and industry experts. We were able to confirm the need for a solution and present the design strategy to these subject matter experts (SMEs) for their input and feedback. This feedback assisted in our design process and enabled us to validate our solution, ensuring a feasible and comprehensive plan of attack for the stakeholders involved. The successful interaction with industry experts allowed for the accomplishment of a vital step in our team's approach to system development.

7. Interactions with Industry Experts and Airport Operators

The best systems are ones that are designed around the user. In order to develop a design effectively, a close relationship between designer and user must be established. This allows for the designer to become acquainted with the problem and to experience firsthand why a solution is needed. One cannot be expected to know how to fly an aircraft by simply reading about it, direct experience is necessary to develop the skills needed to operate the aircraft properly. Likewise, familiarity of the problem will cultivate the way to an effective design. This knowledge is gained through interaction with the system users. For our team, user involvement has been a primary and essential part of the design process.

Throughout the design phase, we conferred with various industry experts and operators. Once an initial concept was reached, pursuing a topic with NVGs, interactions with these SMEs helped to narrow our design scope. In the sections that follow, we describe a series of phone-based interviews and their influence on the direction of our project work. Then, we describe the data collection conducted during our visit to a helicopter flight school that offers NVG training.

7.1 Telephone Interviews

The first step in reaching out to industry was contacting the FAA. Over-the-phone interviews were scheduled and began with Edwin Miller of the 135 Air Carrier Operations Branch (AFS-250) of the FAA. Drawing from his current knowledge of the industry, as well as his experience as an NVG pilot, he detailed the various aspects of the incompatibility between NVGs and LED lighting. Mr. Miller described how lighting incompatibility is an issue that affects all lines of operation within the FAA and military operators. He shared with us some examples from the Aviation Safety Reporting System (ASRS) database and some military anecdotes. Another key note taken from our discussion is how this problem is technologically simple, but logistically complex. The LED lights that are already deployed are relatively easy to replace or modify, but the cost burden comes from the fact that there are thousands of them, many of which are located in difficult to reach places such as the top of a cell phone tower. After our conversation with Edwin Miller, the gears in our thought process started to turn. How to navigate around this logistical problem was at the forefront of our mind. We then interviewed Alvin Logan, an airport lighting and electrical systems electronic engineer working in the Airport Engineering Division (AAS-100) of the FAA. He confirmed the current subject of concern that Edwin Miller had relayed, regarding the incompatibility issue between LED lighting and NVGs. Alvin Logan informed us that this is an current concern for the FAA and that early in the new year there would be discussions between three major lines of operation, Aviation Safety, Airports and Air Traffic, with the intention of conducting a broad-scoped operational safety assessment on LED lighting. An interesting fact derived from this conversation with Alvin Logan was that there are no standards or requirements for ground-based lighting to be compatible with NVGs. This information resulted in our group making the establishment of a technical standard a fundamental part of our design solution.

After talking with industry leaders and developing the beginning stages of our design solution, we wanted to meet with NVG operators to gauge their viewpoint on this issue and to see how our design solution would impact their operations. We began by contacting Dan Crowe, the owner of Palm Beach Helicopters (PBH), a flight training school in south Florida that offers NVG training. They are currently one of three helicopter training schools in the nation that offer an NVG course. Dan Crowe also owns Aircoastal Helicopters, a helicopter charter company, and throughout his career he has been a pilot for the Palm Beach County Sherriff's Department as well as an air ambulance pilot. His knowledge of the industry and of several entities that operate using NVGs was a great addition to our data input. Through this contact, more SME contacts were established and consulted to gain a better understanding of how NVGs function and the existing problems associated with their use. A teleconference with Adam Aldous, CEO of Night Flight Concepts, confirmed our research of the concerns regarding some LED lighting that is invisible to pilots using goggles. Night Flight Concepts manufactures, sells, and trains pilots on NVGs. Adam Aldous was very aware of this critical issue facing the industry, not only the limitations of NVG flying in regards to LED lighting, but also the safety implications that surfaced because of these limitations.

Once the existence of a problem was substantiated by both the FAA and a manufacturer, we then wanted to interview a user to see how large of a safety issue exists from that perspective. Michael Jamison, an NVG instructor at PBH, agreed to speak with us via teleconference to relate his outlook on the safety factors of flying with NVGs, including NVG-LED incompatibility. He provided two viewpoints, that of a pilot first and then of an instructor. He confirmed that this was a valid problem and expressed how frequently pilots come across obstructions that are not seen through the lens of NVGs due to the type of LED lighting used on obstructions. From an instructing standpoint, pilots are trained to establish a scan (i.e., repeatedly looking outside, then at each instrument, then back outside). When wearing NVGs, this scan technique is modified; they are taught to look through the goggles and see objects while aided, then look out the side of the goggles to see the same objects unaided, verifying what was seen, then look down to the instruments to assure that everything is functioning properly. This is done constantly throughout the entirety of the flight to gather ‘pieces’ from each 40 degree field of view allotted by the NVGs and place them together to form a big picture. This is a crucial part of the training because of its impact on the safety of the flight. Michael Jamison pointed out that when he is instructing, the obstructions that become invisible can, ironically enough, be used as a teaching tool to show pilots how dangerous flying with goggles can be if they are not performing their scan appropriately. After saying this, he quickly added that he would much rather not have these “training tools.” He would much rather that the ineffective LED lighting be replaced if it meant that the safety of the pilot would increase.

7.2 Data Collection at Palm Beach Helicopters

Through both teleconferences, we were able to ask preliminary questions and gather important data as to what the problem is and how the industry currently views said problem. We identified, however, that we would not fully grasp the reality of the issue without experiencing it for ourselves. Contact was made again with the owner of Palm Beach Helicopters (PBH), Dan Crowe, and a request was made to see if we could arrange a trip to their facility to perhaps test the NVGs ourselves. They graciously agreed and this overnight trip was put into motion.

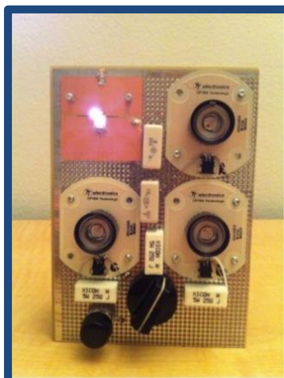

***Figure 7.1*:** Top left, LED and IR light circuit board; Bottom, Obstruction Map.

To prepare for our visit, a circuit board of three LED lights and one IR LED light (see Figure 7.1) was created so that while down in West Palm Beach we could see how the different lights were seen or unseen using the NVGs. A map of all obstructions in the surrounding area of Palm Beach County Airpark, the operating base of PBH, was also created. The map allowed us to ask instructors what obstructions or areas they were most concerned about in their field of operation. Instructor responses will provide a framework to establish which obstructions need to be concentrated on first when implementing our design solution. For example, because NVG operation is primarily conducted in dark areas, an operator may not be concerned with a city area. The lights are too bright around a city and the pilot would not need to use NVGs. Conversely, in a dark area such as the Everglades, more attention would be required to ensure that all obstructions have compatible lighting for NVG operations. Finally, a set of pre-determined questions was created so we could make the most efficient use of our time spent at the school.

Once we arrived, we were greeted by friendly staff and banner that was made just for us (see Figure 7.2). After a quick lunch to acquaint everyone, the work began. Our team was able to sit in on a training ground lab (see Figure 7.3), NVG 101 if you will, which afforded us the ability to ask questions and gain a more thorough understanding of NVG potential and limitations. The course, taught by Michael Jamison, lasted approximately two hours and covered subjects including: NVG components, capabilities, limitations, and

Figure 7-3: NVG ground lab. Top left, helmet and goggle adjustment; Top middle, NVG use; Far right, helmet instruction; Bottom left, group picture with instructor Michael Jamison; Middle, acuity chart; Bottom middle, NVG image.

operations. This time also permitted us to each try on the helmet and goggles configuration that pilots wear and adjust the settings to our own particular standards. Once set, the lights were dimmed and we could see the green image of an acuity chart placed on the opposite side of the room. We then engaged in a series of activities to adjust the sight, read the chart at a far distance then compare the reading to the view at close range. The circuit board of lights was brought into the room and tested while on the goggles. We found that the room was not adequately sized to conduct the experiment properly. We would have to wait until nightfall and bring the equipment outside.

Once the formal training was completed, an informal period for questions and answers followed. During this time, the obstruction map was displayed for the instructor to view and give his input on which areas deserved a greater focus of attention due to their impact on PBH operations, particularly concerning NVG operations. After a short dinner break we returned to take our new knowledge outdoors and then upward to the sky.

Before our flights, we first tested the constructed circuit board of LED lights and IR light outside in a very dark corner of the airport (see Figure 7.4). We were able to see and record the effects of each light through the goggles. Unfortunately, all three lights were actually visible through NVGs. The green and blue LEDs were significantly dimmer than the red LED (which is consistent with the properties of the Class B filter), but all of them could be seen. We speculated that the power of the LED bulbs that we had selected was too high for the distances that were available to us, essentially overpowering the NVG filters and therefore did not accurately simulate real-world conditions. Not all was lost however. During our time on the ramp, we observed a series of LED taxiway lights that were invisible when viewed with NVGs. As can been seen in figure 7.5, the difference between unaided and aided viewing of those lights was quite stark.Palm Beach Helicopters then allowed us to ride along on an NVG introductory training flight, with a pair of goggles in hand, to see for ourselves the issues that arise for pilots in the night sky. We accompanied two certified flight instructors, Chief Flight Instructor James Davies, who was giving the instruction for the flight, and James Hershman who served as the student. Both instructors were very informative and provided us with an educational and fun flight experience. The helicopter that was used is a Robinson R-44 aircraft that has been modified for NVG training. Once in the air, James Davies instructed us on what we were seeing through the goggles and certain things to be on the lookout for. He pointed out obstruction lighting that was hard to see under the aid of NVGs and also directed us to look at lighting that was so bright it caused a blooming effect while on goggles. Two flights were made to accommodate for the size of our team, with each flight lasting approximately 30 minutes. This opportunity allowed us to have a genuine view into the realities of night flying and the safety risks that are involved. Up until this point our research had been very flat and two dimensional. Now it had been brought to life.

Figure 7.4. Top right picture, Circuit board lighting: Top, red LED; Middle, green LED; Bottom, blue LED. Bottom left picture, group picture with James Davies, James Hershman, and the R-44 used for the flight.

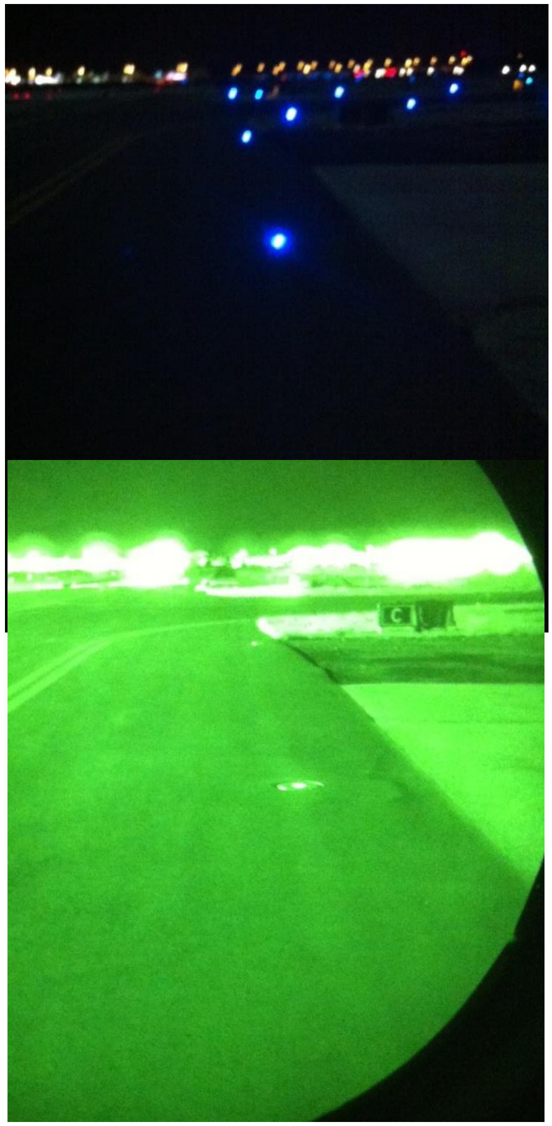

Figure 7.5. LED taxiway lights rendered invisible by NVGs

Each interaction and opportunity granted by the industry experts and operators gave us great insight into the real problem and helped confirm and further our design solutions. Their input was considered and implemented at each stage of contact and their influence toward this project has been invaluable to insure a final design that would fully encompass the needs of each stakeholder involved.

8. Design

The solution to our problem is straightforward – make all of the obstruction lighting NVG compatible. All of the technology required is readily available and affordable (relative to the cost of current obstruction lighting). Roughly speaking, our solution is to change light bulbs.

The complexity of the solution lies in the fact that there are a large number of "light bulbs" located all across the country, most in places that are either hundreds or thousands of feet above the ground. They are owned by companies that do not necessarily have a stake in aviation and are likely unaware of the compatibility problems with NVGs. Furthermore, there exists no mandate, requirement, standard or means of voluntary compliance to obstruction lighting is visible to pilots using NVGs.

To this end, our solution consists of three key activities that must be carried out to address the problem. We make no claim that this is a complete solution; our group does not possess the time, resources or experience to understand and address the multitude of complexities of this problem. However, what we do provide is a systematic and logical foundation that allows this safety critical problem to be addressed incrementally.

We are proposing the tools and enabling systems that will allow stakeholders to contribute to the resolution from the strength of their own expertise and resources rather than laying the entire burden on an individual group of stakeholders. Specifically, SOLV is composed of the three activities described in sections 8.1 through 8.3, below.

8.1 Establish a technical standard

As previously discussed, obstruction lighting standards are set by FAA Advisory Circulars 70/7460-1 and 150/5345-43. Neither of these documents makes any mention of NVG compatibility. The major implication of this fact is that there is no recognized objective standard that can be used to determine if a particular light is compatible with NVG operations.

Without addressing this deficiency, any regulatory or voluntary measure employed to address NVG compatibility will not be effective as there is no way for obstruction lighting owners to guarantee compliance. Without scientifically validated standards, any attempt at compliance may not be sufficient or worse, be too bright for NVG operations and actually exacerbate the problem.

Ultimately the standard established will describe lighting requirements using physical measurements (e.g. lumens, wattage, etc.) However, physical measurements are a necessary approximation of what we're really trying to describe – whether or not a light is too bright or dim for a pilot whether he is aided or unaided.

To bridge the gap between a physical standard (required by lighting manufactures) and subjective human opinion, an experimental study is proposed. The layout can be seen in figure 8.1 and is described below. Fundamentally, the study is attempting to establish a standard that allows an obstruction light to be equally visible under aided or unaided conditions.

The simplest way to increase the visibility of a light to an NVG user without affecting its visibility to someone who is unaided is to add an infrared (IR) light source, such as IR LEDs, like the ones found in a television remote control. IR (especially near-IR wavelengths) are readily detectable by NVGs yet invisible to the naked eye. The question then becomes how powerful an IR light source is required to ensure equivalent visibility whether a pilot is using NVGs or not. Simulations and ground testing can help to determine an approximate power level, but a live-fly experiment will ultimately be required.

Our experiment will consist of a number of trials. In each trial, the helicopter pilot starts at a point far enough away that the light is not visible. Then the pilot will fly towards obstruction without NVGs and records when he can first spot the light. The recorded spot is the max distance that is unaided which is marked on the diagram as Du_{max}. Furthermore, the pilot will continue towards to the obstruction until the light is so bright that it interferes with his ability to see. This is minimum distance unaided which is marked as Du_{min}.

The pilot returns to starting point. The pilot will fly towards the obstruction with NVGs and records when he can first spot the light. The recorded spot is the max distance aided is marked on the diagram as Da_{max}. The pilot will then continue towards to the obstruction until the light is so bright that it interferes with his ability to see then will record the spot. This is the minimum distance aided which is marked as Da_{min} on the diagram.

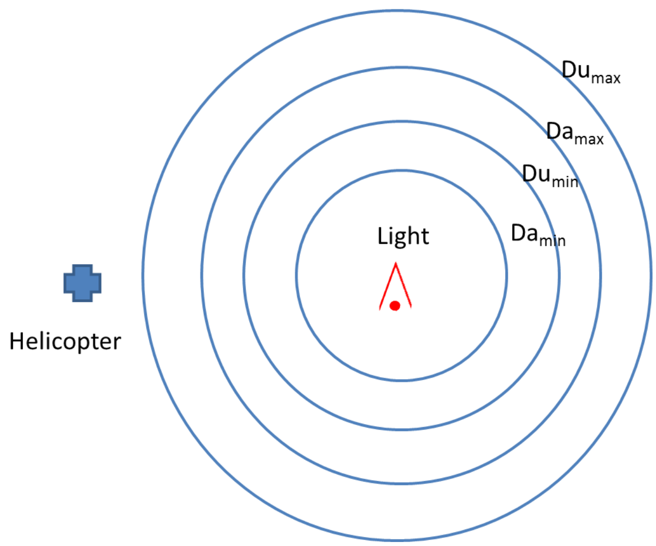

Figure 8.1 Experiment diagram

The aided and unaided values are then compared. The closer the respective max and min values, more likely it is that the obstacle light will be equally visible whether seen by someone with or without NVGs.

To ensure a visibility correlation is established for a wide variety of circumstances, several trials will be required. The two variables to be manipulated between trials include pilot experience level of the pilot (both in terms of overall flight experience and NVG experience) and the altitude of approach.

8.2 Amend the regulatory framework

Once a technical standard has been established, the next task is to determine how it will be implemented throughout the national airspace system and express this plan through policy and regulations. It would be naïve to present a detailed description of the regulatory changes that should be made. These types of policy changes always involve lengthy consultation with industry and public solicitations of feedback to ensure the potential impacts and ramifications of the change are understood.

However, we have developed several general principles that should guide the development of the new regulations. They are:

1. Only LED lighting will be affected. In the absence of evidence to the contrary, it is assumed that other lighting (incandescent, halogen, etc.) is compatible with NVGs
2. All construction started after the regulations enter into force will have to meet the new lighting standard.
3. All existing obstruction lighting that requires replacement (i.e. the light fails or is damaged) must be replaced with lighting that meets the new standard.
4. Existing obstruction lighting will not have to be converted to meet the new standard unless:
    a. The light requires replacement for another reason (e.g. mechanical failure); or
    b. The lights represent a specific risk to NVG operations (i.e. more than the general risk incurred by all LED lighting).
5. Lighting costs will primarily be borne by the owners of the obstruction. However, the cost will be subsidized by the FAA and NVG operators.

In short, this new standard is an unexpected and unfunded mandate. It would be imprudent to demand immediate compliance. Achieving the overall goal of conversion to NVG compatible lighting would be best accomplished through attrition and life cycling except where safety considerations warrant expedited replacement.

8.3 Prioritize conversion

As alluded to in the previous activity, there are some obstruction lights that will have to be made NVG-compatible as soon as possible. Similar to the overall problem, the difficultly in this activity comes from the sheer volume of candidate lights. In order to properly identify and prioritize lights that need to be immediately replaced, a systematic and repeatable process should be used.

The first step is to identify who is conducting NVG operations. Even if this information is not directly tracked, it can be mined from existing data such as pilot NVG endorsements and NVG aircraft type certificates. Once those operators have been identified, the next step is to determine their area of operations. After that is known, a map of all known obstructions in the area of operations can be generated. The task of prioritizing then becomes a matter of discussing which obstacles represent a flight safety hazard to the NVG operators, using the obstacle map to facilitate discussion.

As briefly discussed previously, we conducted a trial of this activity over the course of our project. Using the publically-available obstruction database (http://oeaaa.faa.gov) , we generated a spreadsheet listing the locations and heights of all obstructions within a 13NM radius of Palm Beach County Park Airport (LNA), the home of Palm Beach Helicopters (the radius was limited by the maximum number of search results the database would return. This limitation would not be present to someone with direct access to the database). The obstructions were sorted into three height categories and plotted on a map using a free website (http://www.multiplottr.com/). The resulting map can be seen in Figure 8.2. We found that this map was helpful in our discussions about which obstructions would be most dangerous if they were lit with LED lighting. One limitation of the database is that is does not track lighting types, so we had to rely on the NVG operator's memory and experience to see which obstructions were lit with LEDs.

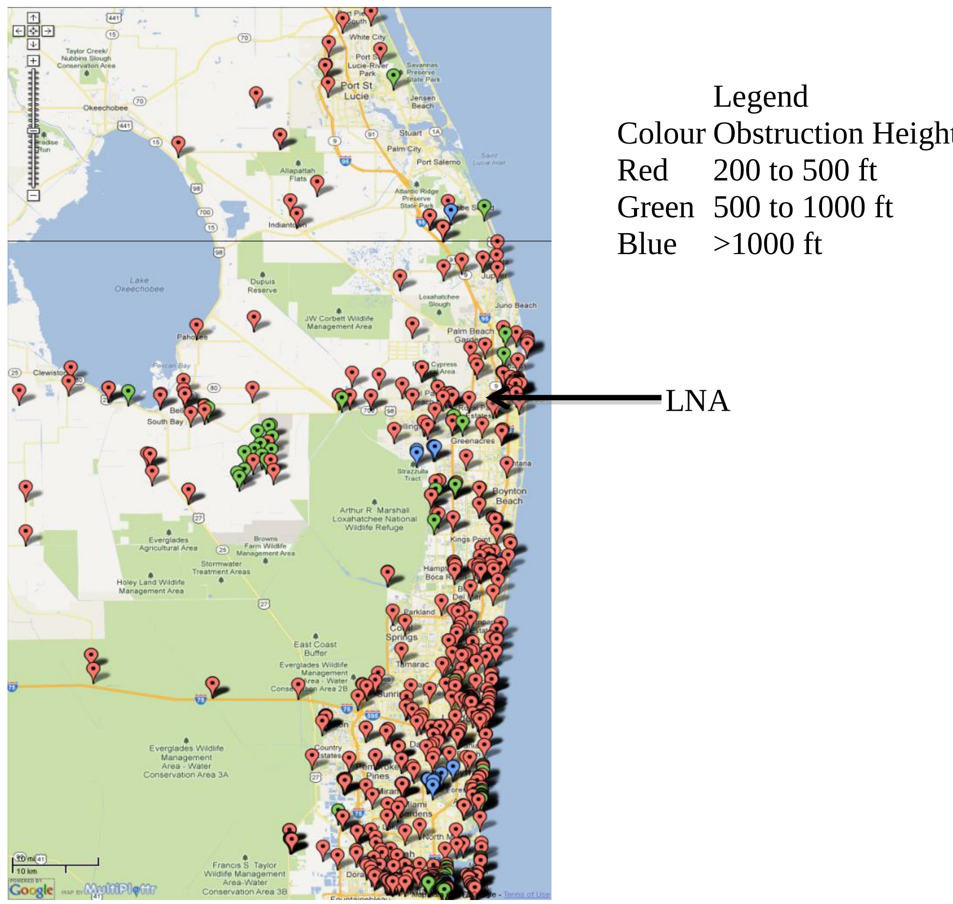

Figure 8.2 Obstruction Map for LNA Airport

9. Cost Analysis

Given that SOLV is intended to address a problem faced by the entire national airspace system, it does not easily lend itself to a traditional cost benefit analysis. The complexities involved with a goal as large as ensuring that every obstruction light in the United State is NVG compatible present a large challenge to the quantification of costs. The information, time and analytical methods required to do such a study are far beyond the scope of this design package. However, there are individual elements that can be analyzed from a financial perspective. Much like the key activities proposed by SOLV, these analyses can serve as a starting point for more detailed studies.

One such element is the flight experiment that would be required to establish a technical standard for NVG-compatible lighting. Table 9.1 below details the expected high-level costs:

Table 9.1
NVG compatibility flight experiment costs

Line Item	Cost Estimate	Estimate Source	Notes
Land rental	$0	N/A	1
Test tower	$150K	Steelintheair.com	2
Flight time	$18K	Palm Beach Helicopters	3
Miscellaneous	$75K	N/A	4
Total	$243K		

Notes:
1 – Government-owned land would be used, likely a test range or training area owned by the Department of Defense
2 – This is the average cost of a cell phone tower. The cost of the test tower would likely be less since it would not require all of the equipment, but demolition costs would have to be considered.
3 – Assumes that each run takes 1 hour, multiplied by 5 test pilots doing 2 runs at 3 different altitudes. Cost derived from 30 flight hours at $600/hr.
4 – Includes salary costs for experiment design, data collection, report compilation as well as logistical costs incurred by the test team (e.g. travel, accommodation, meals)

In addition to being difficult, determining the absolute replacement cost of conversion to NVG-compatible lighting is of questionable utility. A better approach is to examine the difference between existing replacement costs and those that would be imposed by conversion. Obstruction lights do not last indefinitely; their severe operating environment necessitates regular replacement.

The analysis will be conducted using the following facts and assumptions. Most of the assumptions serve to simplify the analysis, but the method could easily be adapted to more detailed information

Facts:

- A standard LED L-810 obstruction light costs $250 and an NVG-compatible one is $350 (source: Flight Light Inc.)
- Installation costs (labour only) are approximately $1500 a tower 400 feet and below. The costs for towers above 400 feet are proportional and vary directly. For example, a 600-foot tower the installation cost would be $2250, equivalent to one and a half 400-foot towers. (source: EMEGC Inc.)

Assumptions:

- Obstruction lights are replaced every 5 years.
- The obstructions located in a 13NM radius around Palm Beach county airport are representative of the NAS.
- All obstructions are skeletal structures using FAA style-A lighting
- L-864 light requirements can be met by using L-810 lights (i.e. the analysis uses just solid beacons rather than the mix of flashing and solid beacons actually mandated)
- Only obstructions above 200 feet AGL require lighting
- The year that an obstruction was registered with the FAA was the year that its obstruction lights were installed

Appendix 1 of AC70/7460 sets requirements for obstruction lights based on which height bracket the obstruction is in. Using the sample data set we see the following distribution:

Table 9.2
Obstruction lights in sample data set (13NM radius around airport LNA)

Height Bracket	Number	Lights required	Total
A1 (151 to 300 ft)	504	3	1512
A2 (301 to 700 ft)	162	7	1134
A3 (701 to 1050 ft)	27	11	297
A4 (1051 to 1400 ft)	1	15	15
A5 (1401 to 1750 ft)	2	19	38
A6 (1751 to 2200 ft)	1	23	23
All	697		3019

Given a 5 year cycle of light replacement, the distribution of useful life remaining in obstruction lighting can be developed. When the installation cost pricing formula (cost = $1500 + (height/400)*$1500, if height < 400 then (height/400) = 0) is applied to each tower in the data set, the total cost is found to be $1164360. Combining these two calculations with the above table yields the current value of the useful life remaining in the obstruction lights.

Table 9.3
Useful life remaining in obstruction lights

Useful life remaining (years)	Number of towers	Percentage of towers	Value of obstruction lights	Value of installation costs
0	126	18	0	0
1	124	18	27171	41917
2	144	26	63399	97806
3	183	21	117741	181640
4	120	17	102646	158353

The cost of converting to NVG-compatible lights on a purely attrition basis (i.e. only converting when the existing light requires replacement anyways) for this sample is $301,900 (number of lights times the difference in cost between the lights). The cost of requiring immediate conversion is the attrition-only cost plus the current useful life values. That cost is $1,092,573.

The usefulness of these numbers is not in the amounts themselves, but rather to give an indication of the effect of compliance deadlines on the cost of conversion. From a cost perspective, attrition-only conversion would be preferred. From a safety perspective, immediate conversion would be preferred. The balance struck between these conflicting requirements must involve a calculation similar to this, albeit performed on the NAS rather than this simplified data set.

The costs associated with conducting the activity of prioritizing obstruction light conversion will primarily be borne by the FAA. This is a consultative process that will require a significant amount of front-end data collection and processing. However, the enabling systems required to conduct such an activity are likely already in place at an enterprise-level organization such as the FAA, so there is likely no acquisition or training costs associated with it. Therefore the only costs will be in the human resource area.

Without detailed information about the FAA's employee productivity or organizational chart, it is difficult to estimate the required staff-hours and associated incremental costs. However, there are a few salient facts known that can provide insight into this estimation. Specifically:

- Funds are allocated to the aviation safety organization to provide safety and risk management consultation to aircraft operators.
- The FAA routinely participates in NVG working groups and conferences where operators and industry are represented.
- The FAA is the owner of the databases that contain information about NAS obstructions as well as NVG operator licenses.

- A project charter was initiated on October 5, 2012 to investigate the feasibility of requiring air ambulance operators to conduct all part 135 operations using NVGs. There are potential synergies between the objects of that project and that of prioritizing obstruction light conversion.

In light of these facts, it is believed that the FAA is well positioned to conduct this activity and that the relatively minor incremental costs could be funded, should the appropriate priority and visibility be given.

With the discourse on costs complete, the benefits of SOLV must be considered. Conceptually, the benefit of our design is that it will reduce the likelihood of aircraft collisions with obstacles due to NVG-LED incompatibility. The cost of these collisions are variable; depending on the size, trajectory and speed of the aircraft, damage to the aircraft would range from severe to catastrophic and damage to the obstruction would vary from minor to catastrophic. However, it is a difficult benefit to quantify for the simple fact that no such collision (attributable to NVG-LED incompatibility) has yet occurred.

This is not to say that such a collision will never occur. Indeed, with the proliferation of both LED obstruction lighting and NVG operations, it is only a matter of time before an accident happens. The LED-NVG incompatibility is clearly and objectively a flight safety hazard that must be addressed. Although the lack of attributable accidents may appear to be a liability, it is in fact an opportunity. One of the key tenets of safety and risk management is to proactively identify and address hazards. With sufficient leadership and foresight, this problem can be addressed in a measured and optimized manner. While it is easier to justify funding in reactive situations, the solution to the problem is usually sub-optimal and of little use to the people who have already been adversely affected by the hazard.

10. Safety Risk Management

The safety risk assessment for SOLV was conducted using the practices codified in FAA AC 150/5200-37, *Introduction to Safety Management Systems (SMS) for Airport Operators*. The FAA's safety risk management process (summarized in Figure 10.1) was applied to each major activity to determine the hazards incurred and the associated risk. For each risk identified, an appropriate mitigation was developed. In the interests of brevity, only the hazards that required detailed risk treatment are discussed and summarized below. Overall, our team found the risk management process to be iterative, requiring risks to be re-examined as the design became more detailed.

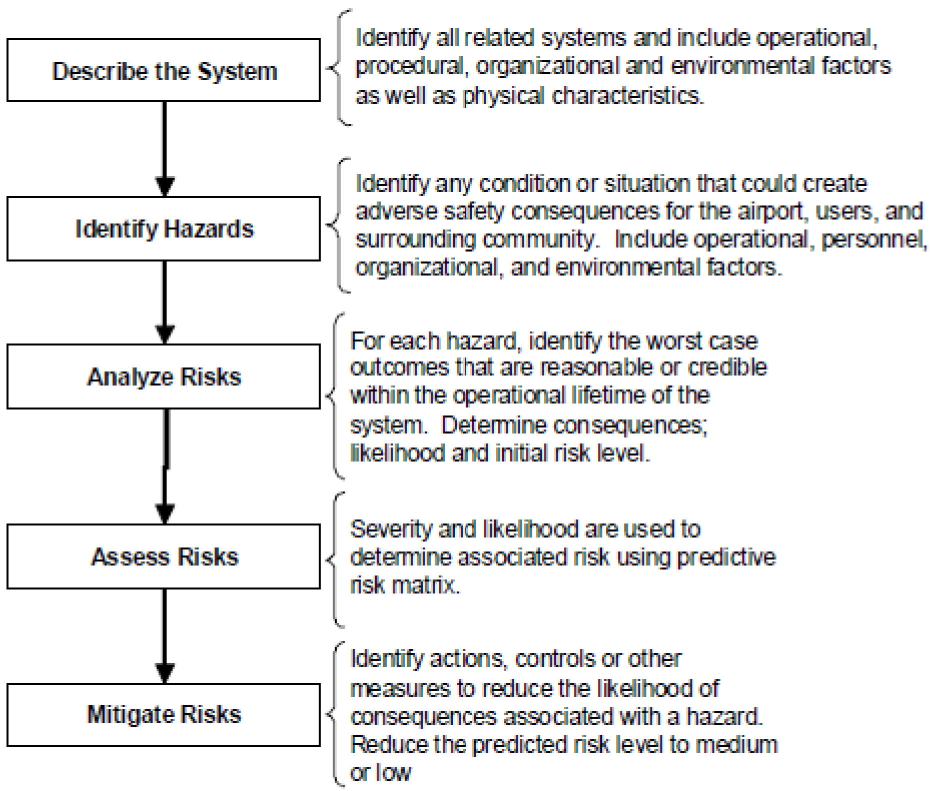

Figure 10.1. FAA's Safety Risk Management Process (adapted from FAA, 2010, p. 4-3)

10.1 Establish a technical standard

The hazards identified in this activity were predominantly associated with the conduct of the flight experiment. Flying, like other forms of transportation, carries inherent risks. However, for the purposes of this risk assessment, we decided that it was more prudent to only consider the hazards specifically caused by the experiment. That is, we used a standard helicopter flight as our "safe" baseline and determined what additional hazards would be present in the experiment's flight regime.

Several hazards were considered, but at the root of all of them was the loss of pilot situational awareness. With the pilot focused on spotting the test obstruction light, the time spent on other flight critical tasks are reduced. The possibility of mid-air collisions, controlled flight into terrain and missed instrument panel alerts are all increased. Additionally, this experiment requires the rapid construction of an obstacle and will increase the usage of a parcel of airspace which may cause conflict with existing air traffic patterns in the area.

The severity of all of these risks was identical (i.e. potential for severe aircraft damage and loss of life), but the probability varied. The most likely scenario involved the pilot losing situational awareness while in close proximity to the test obstruction and accidently striking it. The next likely scenario would be an incident involving an aircraft not affiliated with the experiment, but that would depend on the business of the surrounding airspace.

Mitigation of these risks would be achieved through increasing the situational awareness of pilots internal and external to the experiment. The test pilot would fly with a co-pilot and a test director. The co-pilot would share responsibility for monitoring the position and status of the aircraft and the test director would focus on the execution of the experiment. All three crew members would have the ability to cease the experiment if an unsafe condition was detected.

Pilots external of the experiment would be managed by temporary flight restrictions (TFRs) and notices to airmen (NOTAMs). If possible, pilots would be restricted from transiting through the experiment area while the test runs are in progress. If this is unfeasible, then NOTAMs would be issued to provide details about the air traffic resulting from the experiment and the temporary obstruction.

10.2 Amend the regulatory framework

It is difficult to find hazards in the act of policy writing, especially policy that is geared towards addressing a current risk in the NAS. To ensure due diligence in our safety risk assessment, we expanded our search to include results and impacts of the proposed regulatory framework. One impact is that there will be an increase in the number of lighting replacements carried out as certain obstruction owners will be required to replace their current lighting before the end of its useful life. Installing lights at height is a hazardous undertaking; our policy proposal calls for an increased number of installations, so arguably our actions will increase the likelihood of an accident, at least until the conversion to NVG-compatible obstruction lights is complete.

However, it is important to note that only the likelihood of an existing risk is raised; no new hazard has been introduced. Regardless, this is an instance where a risk is addressed by transfer. Companies that conduct work at height are subject to occupational safety and health administration (OSHA) regulations, which mean the companies themselves are liable to mitigate these risks. If an obstruction lighting installation company determines that there is an impact caused by an increased pace of operations, then it is incumbent upon them to conduct their own risk assessment.

10.3 Prioritize conversion

Similar to the previous activity, the activities involved with proactively identifying obstructions for immediate conversion do not introduce any hazards in and of themselves. One potential impact of this phase is increased complacency amongst NVG operators. If they feel that NVG-LED compatibility issues have been eliminated, then they may potentially become more reliant on aided flight and less vigilant about maintaining concurrent unaided situational awareness.

This hazard would be best addressed by the individuals and organizations responsible for NVG training. The need for conducting scans both through and outside the NVGs is not limited to NVG-LED incompatibility. Flight instructors will have to continue to emphasize the fact that while NVGs provide a great number of advantages during nighttime flying, they also have specific limitations that must be managed through the use of unaided nighttime flying techniques.

11. Conclusion

It is unfortunate that one technology that improves safety of flight and another that provides cost savings have a conflict that poses a risk to safety of flight and incur a significant cost to address. Furthermore, the incompatibility was not fully realized until both systems were released into to the NAS, further adding to the expense and complexity of any resolution.

Currently, the problem is mitigated by procedural training. Pilots are trained to divide their time between looking through and outside their NVGs, mentally combining the aided and unaided images to ensure a complete picture. However, this procedure comes at a cost, adding to the pilot's workload. For a helicopter pilot operating at night, especially a single pilot or an air ambulance operator, this taxes an already scarce resource. While this has sufficed as a stop-gap measure, a permanent solution is needed.

Our proposal, SOLV, aims at introducing a critical safety improvement into the operating environment surrounding airports through three simple phases. It starts by establishing a technical standard to validate the compliance of LEDs with NVG operations. Using this standard, the regulatory framework would be amended in a manner that provides for a fair and equitable transition. Finally, conversion to NVG-compatible lighting would be prioritized by identifying the obstacles with the biggest impact on safety through consultations with the NVG operator community.

We gained a significant amount of experience and understanding from our literature review, industry and subject matter expert interviews, visit to Palm Beach Helicopters, building an LED display to witness the problem first-hand and creating a “proof of concept” obstacle map. This diverse number of activities not only provided the basis for SOLV, but also gave us the confidence that it is the optimal response to addressing the safety of flight risk created by night vision goggles and LEDs.

Appendix A - List of Student and Faculty Contacts

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Appendix B – Description of University

On December 17, 1925, exactly 22 years after the historic flight of the Wright Flyer, barnstormer John Paul Riddle and entrepreneur T. Higbee Embry founded the Embry-Riddle Company at Lunken Airport in Cincinnati, Ohio. In 1965, Embry-Riddle consolidated its flight training, ground school, and technical training programs to Daytona Beach, Florida. Expansion of the University began when a former college in Prescott, Arizona, became the western campus of Embry Riddle in 1978.

In addition to its two traditional residential campuses, Embry-Riddle Worldwide provides educational opportunities for professionals working in civilian and military aviation and aerospace careers. Of today's more than 150 Worldwide Campus locations in the United States, Europe, Asia, Canada, and the Middle East, the majority are located at or near major aviation industry installations, both military and civilian.

Though it began as a school for pilots and aircraft mechanics, the University now offers more than 40 undergraduate and graduate degrees and provides the ideal environment for learning. Degrees available at ERAU include Aviation Business Administration, Aerospace Engineering, Human Factors and Psychology, Safety Science, Homeland Security, Engineering Physics, and more. Even though Embry-Riddle is primarily a teaching institution, research plays an important role for students and industry. The focus is on applied, solution-oriented research. ERAU combines an impressive faculty with state-of-the-art buildings, laboratories, classrooms, and a diverse student population. Embry-Riddle's students represent all 50 states and 126 nations.

As aviation and aerospace continue to evolve, so does Embry-Riddle. The University is committed to the expansion of opportunities for students to work more closely with the aviation industry in the United States and in other countries.

Appendix E – Team Evaluation

Tara Baseil

The FAA Design Competition provided a meaningful learning experience because it prepared me for “real- world” situations that airports are having difficulty solving. It was a great opportunity for the entire group because we learned about teamwork and the industry of FAA.

Challenges that the team encountered were difficulty getting in touch with a major contact. Another challenge was trying to plan our trip to West Palm Beach Helicopters soon enough to be able to gather all of our research for our report.

I learned about major concerns airports have been dealing with. This project helped significantly with the skills and knowledge I need to be successful for entry in the workforce and to pursue further study because it was a “real- world” problem and the group was able to analyze it to see which options were available. Overall, this project prepared the group about expectations within the workforce.

Anne-Claire Blondeau

Many lessons were learned while participating in this competition. First, this competition helped me learn more about the many different issues currently affecting the aviation industry. Participation in the competition also allowed me to put into action the knowledge acquired in the classroom. However, I believe that the most important lessons I have learned during this process include working as a team and interacting with industry experts. Although I have had many opportunities to work in a team setting during both my undergraduate and previous graduate degrees, I believe that each experience is different and offers its own challenges.

As a team, I think that our first biggest challenge was to decide upon a topic. Our team is characterized by a variety of different personal and educational backgrounds. The challenge initially resided in familiarizing every team member with aviation terminology and operations. For example, while very familiar with the world of aviation, I had very little knowledge about the specific world of helicopter operations and night vision technology. After several weeks of brainstorming and discussing our different options with industry experts, we decided to pursue the issue that seemed the most important and critical in our eyes. Our interaction with industry experts truly helped the team with defining the problem and their feedback really helped us shape our solution. Our discussions and visits with subject matter experts were very informative and beneficial to our project. The second biggest challenge faced by the team was understanding each other's perspective and recognizing each other's different background and comprehension of the problem and its environment.

Personally, this experience has taught me about how to engage in this type of project and how to conduct it. I have also learned how to be part of a diverse team and how to ensure proper and sufficient communication between team members. Indeed, I have learned to understand and support everyone's perspective in an effort to develop ideas and solutions that can be useful and constructive to the end project.

Christopher Bryan

In the seven years that have passed since I finished my undergraduate degree, I have spent a significant part of my career working in aviation systems engineering. It was a pleasant surprise that one of the first classes of my graduate program involved participation in this competition, which provides an opportunity for further developing and refining this skillset.

I learned a great deal from the diversity of my team. Our group represented a wide variety of backgrounds and disciplines, so I was exposed to perspectives that I initially found unfamiliar. Key to my understanding of these perspectives was understanding the underlying values and motivations that formed them. This process gave me not only insight into differing viewpoints, but experience in integrating them all to support a common goal.

A corollary to this was the challenges I had with communicating my own perspective, whether within my own team or when interacting with stakeholders. Throughout the competition, I learned my ideas were of little use if they could not be effectively communicated. I found that sharing ideas required thinking them through in an organized and logical manner, allowing them to be readily understood. This had the added benefit of ensuring that I understood the idea myself, which I recognized on more than one occasion.

On the whole, this competition served to broaden my horizons. We chose a problem that involved the implications of introducing emerging technology to a system that affects a wide variety of stakeholders. As within my own team, I learned that such a problem can only be solved by understanding the diversity of perspectives and effectively communicating my own.

Olivia Crowe

The fall of 2012 marked the beginning of my Graduate career. With this new beginning, I embarked upon a domain area that I had little background or experience in, Human Factors Systems Engineering. This semester brought a lot of new challenges that were both welcomed and enjoyed. One such opportunity appeared through the 2012 FAA Design Competition. Our team, the Night Owls, set out to change the world of aviation with an innovative and fresh design. The problem was we didn’t have a design. This was our first hurdle to overcome. The struggle wasn’t to find an area in need of a solution, but rather to find one we could all agree upon. The diversity of areas offered by the competition not only interested and inspired us, they also left us perplexed as too which one to choose. As ridiculous as this sounds, we wanted to participate in all of them. Of course that was an irrational option, nonetheless that was our dilemma. One activity that really aided us in narrowing down what topic we would choose was talking with industry experts and airport operators. One of the Night Owls discovered the issue of LED incompatibility with NVGs through making contact with a FAA representative. This area was so fascinating, are team accepted the challenge and we were off. We still needed more information to develop our hypothesis and the direction we would take in developing a solution. Another Night Owl contacted a local flight school who taught NVG operations to gain their perspective on the issue. Through that interaction more contacts were identified and our project took flight. Along the way we had some difficulties staying in contact with some of the industry experts, but the hindrance to the project was minimal. Overall the experts and operators in industry were invaluable to this project. They helped us every step of the way from our initial proposal to our final product. Without them the value of this project would surely decrease.

Through my participation in this competition, a platform was created for me to learn many lessons. First the skill of researching a topic and gaining the necessary information about said topic to present a valid solution. My background in research is limited at best, but this project aided in broadening that. Secondly, this project facilitated the opportunity to interact with industry professionals, adding to my experience and comfort for future endeavors. I think it is very important to learn how to conduct yourself in a professional manner, especially when you have to reach out to other industries. This experience has helped in preparing me to better understand what to expect when I enter the workforce, as well as, throughout the remainder of my collegiate career. Thirdly I also gained knowledge in how to effectively work on a team. I have done group work in the past, but never to this level. We certainly had our bumps along the way, but through teamwork, each problem was handled and we were able to move forward. In any work environment, teamwork may be required. Now I feel that I have the tools and abilities to perform effectively on any team I join, whether in industry or education. Finally, the information gained from this project was very helpful, not only from our own group work, but in hearing other groups projects as well. The field of aviation is a passion of mine, from flying to airport design, so the more information I can acquire will not only add to my own enjoyment, but also to my level of experience and understanding when I strive to begin my own career in the field of aviation.

While we may not have saved the world, I feel that this competition has opened the door for our voices to be heard and our knowledge to be explored. When something great happens, it is typically the result of previous research, understanding, and others footsteps. Perhaps we are one of those stepping stones that will lead this industry to an even better tomorrow.

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