Radioluminescent Lighting for Alaskan Runway Lighting and Marking

**G. A. Jensen
L. E. Leonard**

March 1985

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(a) State of Alaska Department
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SUMMARY

Alaska and other far northern areas have special logistical, environmental, and economic problems that make radioluminescent (RL) lighting applications, especially in the area of airport lighting, an attractive alternative to electrical systems and flare pots. Tests and demonstrations of prototype systems conducted in Alaska over the past two years have proved the basic technological worth of RL airport lighting systems for civilian and military use. If regulatory issues and other factors identified during these tests can be favorably resolved and if the system and its components can be refined through production engineering, attractive applications for RL airfield lighting systems in Alaska and other remote locations could result.

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INTRODUCTION

Alaska has a land area greater than one fifth that of the contiguous 48 states and a population that concentrates in urban areas such as Fairbanks and Anchorage. However, a significant portion of its population is sparsely scattered throughout the state in small towns, villages, camps, and outposts. These pockets of habitation exist for a variety of reasons: native American traditions, resource development and exploration, and government agency and military requirements. All rural Alaskans have one thing in common: they are at the extreme end of the nation's supply line for goods and services. This separation from the greater economic infrastructure of the nation and the nature of the environment place special demands on the equipment, facilities, and systems installed and used in rural Alaska.

Although similar conditions exist at other U.S. locations, design, construction, and maintenance of federal, state, and privately owned facilities are much more complex and expensive in Alaska. Therefore, a constant effort is required to develop or identify technologies and improve the means and methods that allow users to keep pace with public expectations for increased levels of services and facilities across the state. Radioluminescent (RL) lighting is such a technology. Strong potential also exists in expanding the use of RL lighting to the military in remote, austere, and tactical applications where utility or portable electrical power is unavailable or difficult to obtain.^(1,2) Research and development incentives for both military and civilian uses have been identified, and development work to provide lighting that meets these needs is under way.

This research is sponsored by the U.S. Department of Energy (DOE), U.S. Department of Defense (DOD), and State of Alaska Department of Transportation and Public Facilities (DOT&PF).⁽¹⁻³⁾ A technical working group (TWG) has been formed to aid DOE in ensuring that the objectives of the various interests are met. Membership in the TWG is by invitation and consists of the DOE-Headquarters program manager, who chairs the TWG, representatives from

participating DOE laboratories,^(a) DOD user agencies, the Alaska DOT&PF, and other users and interested parties.

The purpose of the work reported here is to describe the potential for RL lighting applications in Alaska and to discuss the demonstrations and tests that have been completed in Alaska. Alaskan needs, primarily those of the civilian sector, will also be discussed. Since military needs parallel those of the civilian sector, they will be addressed only as required to provide clarity in the discussion or when they differ substantially from the civilian requirements.

(a) Pacific Northwest Laboratory (PNL), Richland, Washington, is operated for DOE by Battelle Memorial Institute; and Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee, is operated for DOE by the Martin Marietta Company.

BACKGROUND

In the decade following Alaskan statehood in 1959, the population of Alaska began to rise significantly. The influx concentrated in urban areas, primarily around the oil and gas activity of the Cook Inlet area. When oil was discovered on the North Slope of Alaska in 1968, a new growth spurt occurred, prompting a closer investigation of technologies that could be used in the more remote parts of the state. Meanwhile, most rural communities continued to remain primitive and isolated from the rest of the state.

In the 1970s, two major factors drastically altered the complexion of rural Alaska: 1) the Alaska Native Land Claims Settlement Act of 1971 and 2) the construction of the TransAlaska Pipeline and the bringing of the Prudhoe Bay oil field into production. The result was that by 1980 rural Alaskans were politically and economically alert, demanding and receiving increased levels of sophisticated public services and facilities funded and sustained with state oil revenues and receipts from local and regional native corporations. Rural residents were more affluent and mobile, often traveling both between rural communities and to and from urban centers.

The 1980s were barely under way when world oil prices produced a windfall for state revenue. Initially this situation promised to be the case for the long term; today, however, Alaska faces a declining revenue forecast resulting from the international oil glut and the inevitability of depletion of the Prudhoe Bay field and lowered expectations of the resource. At the same time, the events of the past few years have created high public expectations for sophisticated public facilities and services, especially in rural Alaska, which in many ways has just begun to merge into the mainstream of U.S. economic and social activity.

With these considerations in mind, the providers of capital improvements and those who will maintain those improvements and the existing inventory of state- and federal-owned facilities must be very selective in use of dollars. State governmental organizations are attempting to meet this challenge by identifying and, where necessary, developing new technologies such as RL

lighting that will lead to the more efficient use of resources while continuing to improve the quality of public facilities and services.

RL LIGHTING PRINCIPLES

The fact that radiation produced from radioisotopes can be used to excite phosphors that, in turn, emit visible light has been known for many years.^(1,4,5) Beta particles (electrons) are produced by the selected isotope during its decay to form another element. These electrons strike a phosphorescent material, such as zinc sulfide, that contains a small quantity of impurity, such as copper, silver, or cadmium, and are absorbed. Light is produced when the energy from this absorption is released (Figure 1). Other forms of radiation can also be produced during the decay process; for example, alpha particles, neutrons, and gamma rays. Alpha particles are helium nuclei, which are emitted at high velocity. Gamma rays are a form of electromagnetic radiation similar to x-rays but with a higher frequency and greater penetrating power, requiring shielding. If an isotope is to have a practical value as an energy source for self-powered lights, it should have the following characteristics:

- a relatively long half-life
- no emission of alpha particles, neutrons, or gamma rays or be easily shielded
- production of a stable daughter; for example, a nonradioactive isotope

FIGURE 1. Technical Principle of Radioluminescent Lighting (gas - tritium or krypton-85; solid - promethium)

- low chemical and radiological toxicity
- a modest or low cost.

Isotopes that could meet these requirements are listed in Table 1. Krypton-85 and promethium-147 have only been used in special applications and test situations. Tritium meets all of the above requirements and is, therefore, used in a variety of commercially available products in various applications.

Tritium gas can be encapsulated in a glass tube or container coated on the inside with a zinc sulfide phosphor. Uses for this type of light source include exit and other self-powered warning signs for buildings, aircraft, and light standards in the photographic industry. For example, lights containing from 4 to 30 curies of tritium have been used on commercial aircraft and in public buildings in emergency exit signs since the mid-1960s.⁽³⁾ The primary advantages of RL lighting are:

- The lighting requires no external source of power; thus, it is not subject to power failure or interruption.
- The lighting does not burn out or require wiring; thus, the units are self-contained and maintenance is minimal.
- Supply problems from short shelf life component replacement, such as batteries, are reduced where temporary or emergency lighting is required.
- The lighting can function under many severe environmental conditions such as temperatures below -70°F.

TABLE 1. Possible Isotopes for Self-Powered Illuminators and Relevant Properties^(a)

Isotope	Half-Life, yr	Maximum Beta Energy, MeV	Gamma Ray, %	Chemical Toxicity	Radiological Toxicity	Remarks
Tritium (H ³)	12.4	0.018	nil	nil	very low	Low energy. Ideal for luminous paint. Low cost. Easy to handle. No shielding beyond containment required.
Promethium-147	2.6	0.23	nil	nil	medium	Expensive. Short half-life. Contaminating gamma ray emitting 146pm and 148pm present.
Krypton-85	10.7	0.67	0.5% of 0.5 MeV	nil	low	Inert gas. Some shielding required. Expensive. Encapsulation can discolor because of radiation.

^(a) See References 3 and 6.

RL LIGHTING DEVELOPMENT AND APPLICATION IN ALASKA

The research conducted to date has identified the following areas where RL lighting could be of practical use in civilian facilities and military operations:

- signs and markers in buildings
- signs and markers in highway, roadway, harbor, and coastal marine applications
- obstruction markers for emergency and construction applications
- obstruction markers for aviation
- airport signs, markers, and airfield edge and threshold lighting (both marine and terrestrial)
- aircraft landing aids
- other military applications.

Of the uses listed above, only the last three have received serious investigation by military and civil organizations in Alaska. This is not because the other applications are less important but because airfield lighting is currently a critical issue. For the state, self-powered lighting has a foreseeably significant economic impact on state-owned airfields, the aviation industry, and the public. For the military, it has a major benefit in meeting tactical and emergency airfield needs. Efforts have therefore concentrated on airfield lighting as it would be applied in rural or tactical airfields. The intent is to implement the airfield lighting systems before other applications are fully investigated.

THE NEED FOR RL LIGHTING IN THE NORTH

In the winter many of the land- and water-based transportation routes in Alaska (and the Arctic) become impassable. For much of the North, air transportation becomes the only alternative. Winter weather and the short amount of daylight at high latitudes severely limit the hours that commercial or military aircraft can operate at unlighted runways, and only a small fraction of

existing runways are lighted (Table 2). As a result, commercial carriers must have more aircraft and more pilots available to operate during the limited daylight hours or unreliable batteries or power systems must be used at tactical military airfields during field operations or emergency conditions. These factors severely raise costs and put added pressure on civilian or military operations and pilots to complete missions in marginal conditions. Inefficiency and safety could be significantly improved if more civilian airfields and tactical runways were equipped with self-powered lights. Ground maintenance and operations are also affected by equipment and batteries that fail in the cold.

SYSTEM ALTERNATIVES

Currently, two types of lighting are commonly used to aid commercial night operations in Alaska:

- The Federal Aviation Administration (FAA)-approved medium-intensity runway lighting (MIRL) or high-intensity runway lighting (HIRL) as

TABLE 2. Number of Alaskan Airports

Land-Based

Lighted airports operated by DOT&PF	75
Lighted airports operated by military and Coast Guard	15
Lighted airports operated by others	<u>19</u>
Total number of lighted airports	109
Airports operated by DOT&PF	199
Airports operated by other state agencies	44
Airports operated by nonmilitary others	<u>442</u>
Total number of general aviation airports	685
Total number of airports operated by military and Coast Guard	67
Total number of land-based airports	752

Land- and Sea-Based

Total number of airports in Alaska	~1,000
------------------------------------	--------

described in FAA Advisory Circular #AC 150/5340-24. These lighting systems include electric incandescent runway edge and threshold lights, blue taxiway lights, a rotating locator beacon, and a lighted wind direction indicator.

- Flare pots or lanterns for night Visual Flight Rules (VFR) for only nonpassenger-carrying commercial aircraft--Part 91 of the Federal Aviation Regulations (FAR)--or under special permission granted a carrier by FAA under Part 135.229 of the FAR if passengers are aboard. This system consists of flare pots or lanterns spaced at 400-ft intervals along both edges of the runway and some means of communicating wind direction information to the pilot.

MIRL and HIRL systems are specified in detail and can only be modified by special waiver from the FAA in Washington, D.C. The use of flare pots and lanterns is interpreted more loosely by the regulators and can be modified within the jurisdiction of a particular region of FAA, such as the Alaskan region. Permanent military airfields have requirements similar to those of the FAA for HIRL and MIRL. Two additional portable systems are available for tactical or emergency use:

- Battery-powered beanbag lights are compact and can be placed as required on the runway.
- Portable hand-wired runway lighting systems are powered by conventional diesel- or gasoline-fueled generators. The lights are mounted on stakes and placed along the runway as required. Exposed wires suffer damage in arctic weather.

As an alternative civilian and portable military system, RL lighting consisting of RL edge and threshold lights, blue RL taxiway lights, RL visual approach slope indicators, and RL-lighted wind direction indicators has been evaluated. The implementation strategy for using the RL system in Alaska is:

1. Use of the RL system would begin at selected presently unlighted rural runways as an alternative to flare pots or lanterns (under Parts 91 and 135 of the FAR) or at tactical runways in place of beanbag lights or portable systems. After a period of satisfactory use in Alaska, the

users would probably seek federal approval to use RL systems as substitutes for MIRL systems.

2. When the RL system has gained full FAA acceptance, the state would accelerate its installation rate at unlighted airports and begin replacing particularly troublesome electric systems. As existing electric systems reached the practical limit of their life cycles, the state would make further replacements with RL lighting systems, working toward eventual standardization of the RL lighting system. Military use of the RL system would also expand in parallel as more systems became available.

RL LIGHTING DEMONSTRATIONS AND EVALUATIONS

The following sections illustrate the results of demonstrations and evaluations of RL lighting systems that were conducted during the winter of 1983-84 and the following summer at several locations in Alaska and near Richland, Washington.

WINTER DEMONSTRATIONS AND TESTS

The iterative process of design modification of tritium-powered RL systems for airfield lighting and marking that began in 1982 has produced a prototypic system for use at tactical military airfields and rural Arctic and sub-Arctic airfields. This system resulted from several short-term civilian and military evaluations in Alaska and a long-term civilian evaluation at Central, Alaska, during the winter of 1983 and 1984.

RL lighting panels, superwands, and wands used in these tests are shown in Figures 2, 3, and 4. The lighting panels and superwands incorporated a new tritium tube design that was developed by ORNL during 1983 in response to the need for greater brightness identified during tests and evaluations conducted at the "Brimfrost 83" exercises.⁽⁷⁾ Preliminary design of the support fixtures and hardware was initiated by Alaska DOT&PF and PNL personnel and finalized at ORNL.

Evaluations using a prototype of the panel as the basic light element and supporting fixtures were made at Camp Mackall, North Carolina, during the fall of 1983. Observers and pilots reported they could see the lights from 4 to 6 miles. The omnidirectional superwand (Figure 3) was developed during this period and represents an improvement over the first-generation wand used during "Brimfrost 83" testing (Figure 4).⁽⁷⁾ Since response to the panel and superwand was good, the lights were brought to Alaska for winter tests and evaluation.

A military and civilian test program was conducted in Alaska from November 19, 1983, through February 19, 1984 (Table 3). At the end of the test, the lights were removed from Central, Alaska, to Anchorage and returned to the "lower 48" for further testing.

FIGURE 2. Radioluminescent Lighting Panel

FIGURE 3. Radioluminescent Superwand

FIGURE 4. Radioluminescent Wand

The lights were installed at several locations for military evaluation.^(a) The basic configurations of the lighting system used in these tests are shown in Figures 5 and 6. Both configurations were modified periodically by increasing or decreasing the number of lights in the threshold area to determine where the pilot sees the lights (acquisition) and can define (use) the lights or landing aids. Since these evaluations were primarily for military use of the lights, most of the flying was done with the runway configured as shown in Figure 5. This configuration is designed to meet Military Airlift Command regulations for nighttime operations. Military pilots reported they were able to see the lights from 3 to 6 miles distant and found the runway marking usable for alignment and landing from 2 to 6 miles away. Some difficulty was experienced

(a) Alaskan Air Command (AAC) report, Improved Tritium Radioluminescent Lighting, February 1984, prepared by L. J. Hult, Major, U.S. Air Force Chief, Operations Services Division, and C. L. Bupp, Captain, U.S. Air Force Chief, Maintenance Management and Industrial Engineering Division, issued by HQ AAC/DOOS, Elmendorf Air Force Base, Alaska 99506.

TABLE 3. Summary of Military and Civilian Test Program in Alaska
(November 19, 1983, to February 19, 1984)

Test Location	Test Date	Aircraft	Sorties		Runway Configuration	Acquisition Distance, mi	Temp., °F	Weather			Moon
			Landings	Flyovers				Wind	Visibility	Precipitation	
Allen Army Airfield	Nov 19	Cessna 208	8-10	--	Civilian	1-3	-9°F	Light and variable	Clear	0	Full
		C-12	1			3-4			15+ miles		
		UH-1	1-4			2-3½					
	Nov 20, 21	0-2	0	2	--	2-5	Cold	High turbulence	Clear	0	Full
	Nov 22	0-2	Several	Numerous	Military	4-5	Cold	High	Partly cloudy	0	Full
Donnally Landing Zone	Nov 23	C-12	2	Numerous		4-6					
		Cessna 208	2-4		Military	1½	Cold	None	Cloudy	Snowing hard	--
		C-130	8-10	--		2-3(a)					
	Nov 28	Flying	--	--	--	--	42°F	40+ mph	Cloudy	--	--
	Nov 29	cancelled									
Allen Army Airfield	Nov 30	C-130	20	--	Military	3-4(a)	40°F	20+ mph	Cloudy	--	--
	Dec 1	C-130	30		Military	3-4(a)	40°F				
	Dec 2	Flying	None				10-15°F	Light	Cloudy	Heavy snow	--
		cancelled									
Allen Army Airfield	Dec 5	A-10	0	15-20 miles	Military	4+	15°F	Calm	15+ miles	0	Broken cloud cover
	Dec 6	A-10	0	24 miles	Military	3-6	15°F	17-20 knots; gusts to 26 knots	10+ miles	0	Broken cloud cover
Eielson AFB	Dec 12	A-10	8-10	25	Military	4+	-30°F	Calm	15+ miles	0	60% moon
	Dec 13	A-10	8-10	20-25	Several(b)	4+	-30°F	Calm	15+ miles	0	70% moon
	Dec 14	A-10	2-4	10-15	Several(b)	4+	-30°F	Calm	15+ miles	0	70% moon
Central, Alaska	Dec 19	Several	Several		RL civilian	3-7		Varied			
	Feb 8	Cessna 206	2-3	--	RL civilian	3+	-34°F	Calm	15+ miles	Thin	Quarter moon
		Cessna 206	2-3		RL civilian	3+					
					Flare pot V lead-in						
		Cessna 206	2-3		RL civilian	3+					
					Flare pot Y lead-in						
	Feb 9	Cessna 206	2-3		RL civilian	1½-2	-34°F	Calm	2 miles	Indefinite	Cloud cover
					RL lead-in						
		Cessna 206	2-3		Flare pots	2-3					
	Feb 15	Cessna 206	Several		RL civilian	2-4(c)	-34°F	Calm	Unlimited	0	Full moon
		Cessna 206			VASI	1½-2 (usable)(c)					
		Cessna 206			Flare pots	4-5					

(a) C-130 pilots were only allowed to fly a short final approach and saw the lights upon turning to align with the runway.

(b) Primary purpose of these tests was to evaluate and attempt to improve acquisition of the visual approach slope indicator (VASI).

(c) Purpose of these tests was to evaluate several VASIs.

FIGURE 5. Military Runway Configuration

FIGURE 6. Civilian Runway Configuration Tested at Central, Alaska

by A-10 pilots during periods of high winds, but most felt that they could have landed to the lights under these conditions if they had been permitted to do so. C-130, O-2, and C-12 pilots reported no difficulty landing and generally rated the RL lighting satisfactory to outstanding. Many A-10 pilots also gave the lighting system an outstanding rating. On several occasions, a visual approach slope indicator (VASI), shown in Figure 7, was evaluated. Military pilots reported they could see the light from the VASI from 1 to 2 miles out but found it unusable. Attempts to increase the light output of this VASI did not improve the acquisition or usefulness of the system.

The lights were installed on the runway on December 19, 1983, at Central, Alaska, and were removed on February 21, 1984. The civilian configuration was

FIGURE 7. Visual Approach Slope Indicator

tested at Allen Army Airfield (Figure 6) before installation at Central. A 15-watt strobe beacon was used as a navigational aid to bring pilots to the general vicinity of the airfield. This beacon, powered by the 110-volt building power, was located on a DOT&PF building approximately 1/4 mile from the airfield. A RL glide slope indicator (Figure 7) and wind indicator (Figure 8) were also installed later in December. Evaluation questionnaires were provided to air taxi and other pilots randomly flying to the Central airstrip. A summary of the questionnaire returned for evaluation from pilots and passengers is presented in Appendix A. In general, the pilots reported that they could first see the runway from 2 to 5 miles away. Nominally, the acquisition distance averaged about 3 miles and visibility for alignment and landing was from 1 to 3 miles. The VASI was usable from a distance of 1/2 to 1 mile, and the wind "T" was unusable. There was an unplanned medical evacuation completed on New Year's Eve that would not have been possible without the RL runway lights. Correspondence relevant to the usefulness of RL lighting in this evacuation is presented in Appendix B.

The test team and FAA flight standards personnel evaluated the RL runway lighting system and navigational and landing aids such as alignment or lead-in lights, strobe, flare pots as edge markers and lead-in lights, various VASI configurations, and combinations of these various landing aids. The flare pots were evaluated to determine whether they could be used to lead pilots to the airfield if the strobe failed. In all approaches, the RL runway lights were first seen from approximately 3-1/2 miles away, alignment was possible at 3 miles away, and positive runway definition occurred at approximately 2 to 2-1/2 miles away. When visibility was reduced, acquisition and visibility of the lights were reduced proportionally. In clear weather, pilots normally had full vision of the runway at 2 miles. Flare pots worked well for runway alignment but were not judged as effective a navigational aid as the strobe. The strobe could be identified from 7 to 11 miles away compared with 4 to 5 miles for flare pots. The RL glide slope indicator (Figure 7) was normally not

FIGURE 8. Radioluminescent Light Wind Indicator

clearly visible from more than 1-1/2 miles away and was difficult to use beyond 1/2 mile. RL lights for runway alignment were preferred over flare pots since night vision was not compromised. Use of alignment lights did not improve acquisition distance but significantly improved the ability to align the aircraft earlier than with edge lighting only. Flare pots were found to be visible from about 50% further than RL lights. Neither flare pots nor RL lighting was acceptable as a navigational aid, but the strobe light (which is visible from 7 to 11 miles) was entirely usable for this purpose. The reliability and permanent nature of RL lighting make it an overwhelming choice over flare pots as a landing aid.

One evening of testing was devoted to evaluating several VASI configurations. The glide slope indicators (Figure 9) were positioned 500 ft down the runway with 10 ft between front racks (when two vertical racks were used) and 57 ft between the front fixture and the back fixture. The pilots judged all systems from 1/2 to 2 miles away. The DOT&PF observer and one of the FAA pilots flying in the aircraft regularly saw the glide slope indicator (Figure 9d) and found it usable from 1-1/2 to 2 miles distant. It is important to note that the most distinct and easiest configuration to use was not necessarily the ones producing the most light (Figure 9a, b, c). Pilot comments indicated that the L configuration (Figure 9d) was easier to become accustomed to than the top hat (Figure 7). The pilot who reported having problems seeing and using the glide slope indicators felt that his astigmatism affected his vision enough to reduce his acquisition and ability to use the system.

TAXIWAY LIGHTS AT FAIRBANKS INTERNATIONAL AIRPORT

Blue superwand taxiway lights were installed at 150-ft intervals on one of the taxiways on the south side of the main runway at the Fairbanks International Airport. This taxiway is used by small air carriers and private aircraft. Response to this installation was good; however, because the lights are quite dim, the 150-ft spacing appeared to be inadequate. Additional lights were supplied by ORNL for installation on the runway. The support fixtures of several of the lights were struck by snow removal equipment or other vehicles; however, the lights were not damaged and have been reinstalled for further testing.

FIGURE 9. Configurations of Glide Slope Indicators Evaluated

RL LIGHTING TESTS AT HANFORD ARID LANDS ECOLOGY (ALE) RESERVE

RL lighting panels incorporating the newer tritium tube design developed by ORNL were evaluated at the ALE Reserve near Richland, Washington. Some of the support fixtures were those designed for the 1983-84 Alaskan testing. As a result of static and photographic evaluations, a new support fixture was designed for flight evaluations conducted near Richland, Washington, during late September and early October 1984 (Figure 10).

Using the older fixtures, the lights were evaluated photographically and visually using Rattlesnake Ridge on the Hanford ALE Reserve to simulate elevations and flight pattern locations encountered by pilots during base and final approaches. The action plan for this work is presented in Appendix C. Two runway lighting configurations and three glide slope indicator designs were

FIGURE 10. Light Fixture Evaluated Near Richland, Washington

evaluated using roadways to simulate runways. Photographs were taken from 0.33-, 0.65-, 0.77-, 1.0-, 1.4-, 1.5-, and 1.9-mile distances on the runway centerline and 0.48-, 1.1-, 1.4-, 1.6-, and 1.8-mile distances at a 25° angle to the centerline to simulate the base leg of the approach. Elevations above the runway were chosen to simulate the elevation the pilot would be above the runway using a 3° approach angle during descent.

Over 100 photographs were taken; five typical photographs, taken at distances of 0.33, 0.77, 1.0, 1.5, and 1.9 miles, are presented in Figures 11 through 15. Additional work was performed using photographic techniques to determine the received light density at various locations. These data are being evaluated and will be used with photometric measurements of individual panels to model the field of light density at different locations. This information will be used to develop a computer simulation to train pilots and other users of the lights.

SUMMARY OF DEMONSTRATIONS AND EVALUATIONS

The information obtained in the military and civilian testing in Alaska during 1984 and findings of these tests can be summarized as follows:

- Acquisition distance of tritium RL lights ranged from 2 to 5 miles for civilian pilots and from 3 to 6 miles for military pilots, with some pilots reporting acquisition at greater distances.
- Runway definition occurred for civilian pilots from 1 to 3 miles and for military pilots at distances of 2 to 6 miles.
- Alignment can be enhanced using runway alignment (lead-in) lights; the use of these extra lights may be more effective than increasing the light emission from the threshold area.
- A navigational aid, such as a strobe light, is needed to lead civilian pilots to the airfield. Once the pilot is in the vicinity of the airfield, the RL lights are a good landing aid.
- FAA flight standards pilots evaluating the lights felt that they could be used with operator specifications and pilot training. A reliable wind indicator and a beacon or strobe as a navigational aid are needed.
- The lights worked well in Alaska under the weather conditions of the tests. More testing may be needed (for example, in fog, rain, or other conditions) before full FAA approvals are given. Maintenance was minimal and only involved cleaning once in a while and snow removal. Thin (less than 1/16-in.) hoarfrost layers on the light cover enhanced light output. Evaluation of thicker layers of hoarfrost is needed to clearly define problems from this phenomenon.
- An improved glide slope indicator is needed. The top hat configuration (Figure 9) was somewhat confusing and difficult to use. Evaluation of an L-shaped configuration showed promise, but further work in this area is needed.
- Blue RL lights show promise for taxiway purposes. A closer spacing than the normal 150 ft is probably required unless the light output can be improved.
- Pilot vision may be important. This factor was identified by one of the FAA flight standards pilots and is supported by the lower response of older pilots as compared with younger observers in the aircraft.

FIGURE 11. Typical Photograph Taken at a Distance of 0.33 Mile from RL-Lighted Runway

FIGURE 12. Typical Photograph Taken at a Distance of 0.77 Mile from RL-Lighted Runway

FIGURE 13. Typical Photograph Taken at a Distance of 1.0 Mile from
RL-Lighted Runway

FIGURE 14. Typical Photograph Taken at a Distance of 1.5 Miles from
RL-Lighted Runway

FIGURE 15. Typical Photograph Taken at a Distance of 1.9 Miles from
RL-Lighted Runway

FIGURE 14. Typical Photograph Taken at a Distance of 1.6 Miles from
RL-Lighted Runway

ISSUES AFFECTING RL LIGHTING SYSTEM USE IN ALASKA

Issues affecting the use of RL lighting systems in Alaska include: cost, acceptance and utility of the system, and regulatory and FAA approvals.

COST

The installed capital cost of a conventional MIRL system presently ranges from as low as \$100,000 to as much as \$300,000 in rural Alaska.^(3,8) This high and variable cost is due mostly to the degree of remoteness of the airport and the complexity of providing a suitable electric power source. Maintenance costs for MIRL systems currently installed in Alaska are also very high and can exceed the original capital cost in a very few years.

RL lighting systems suitable for rural Alaskan applications are expected to have an installed capital cost ranging from \$80,000 to \$150,000.^(3,8) This estimate reflects the present cost of tritium of approximately \$1.10 per curie. Thus, the estimated installed cost may be less than that of a conventional system. Maintenance and operation costs for RL systems over the system's lifetime are estimated to be less than 35% of the original capital cost, substantially reducing the total cost.

Market potential will be affected by the supply and cost of tritium. Currently, the supply of tritium is limited and costs are relatively high. If a tritium supply were available to produce the lighting systems identified in Table 4 with the idea that volume sales would result in lower prices, capital costs for runway lighting would be reduced substantially.

ACCEPTANCE AND UTILITY OF THE SYSTEM

At the present time, a prototypic RL airport lighting system exists that is effective and useful. The system has been evaluated in Alaska and elsewhere, and refinements that must be made to the basic concepts of fixture design, materials use, etc., have been identified. In Alaska, those needs are primarily for durable and low-cost systems in a package that is acceptable to

TABLE 4. Possible Implementation Schedule (per year basis)

<u>Time</u>	<u>Number of Conventional Systems Installed</u>	<u>Number of RL Systems Installed</u>	<u>Number of Conventional Systems Replaced/ Modified with RL</u>	<u>Number of RL Systems Upgraded/ Modified</u>	<u>Tritium, kCi</u>
1985-1986 with FAA Part 135 approval	3 to 5	3 to 5	0	0	200 to 500
1987-1989	3 to 5	3 to 5	0	0	200 to 500
1990-1992 with full FAA approval	0	5 to 10	2 to 5	2	500 to 1500
1993-1995	0	10 to 15	5 to 10	3 to 5	1500 to 2500
1996-2000	0	15 to 20	10 to 15	10 to 20	2500 to 3900

the appropriate regulatory agencies. The health and safety factors related to the lights have been reviewed by several organizations, and published results indicate that the environmental hazards of using the lights for runway applications are minimal. (2,9,10)

REGULATORY APPROVALS

For RL airport lighting systems to flourish in Alaska, two main regulatory considerations must be addressed:

- Users, such as the State of Alaska, would prefer to minimize their involvement with the regulatory process. Thus, suppliers and/or manufacturers would be expected to obtain general licenses from the U.S. Nuclear Regulatory Commission on any RL products they wish to sell in Alaska.
- RL airport lighting systems in Alaska and elsewhere need to be accepted by the FAA as an alternative to conventional lighting systems for appropriate applications. FAA acceptance would ensure product acceptance and, perhaps most importantly, would qualify the RL products to be specified on federal aid projects.

FEDERAL AVIATION REGULATIONS PART 135 APPROVAL

The RL system must receive operational exposure in Alaska if the potential benefits are to be realized. In the civilian sector, state and FAA cooperation is needed to permit use, though perhaps limited at first, of the system by air taxis in a passenger-carrying operation. This process could begin with the Regional FAA Flight Standards Authority in Alaska, who could develop a policy and action plan that would permit use of RL lights under Part 135.229 of the FAR as an alternative to flare pots or lanterns. The demonstrations and tests conducted at Central, Alaska, during January and February 1984, an FAA evaluation completed at Richland, Washington, during September and early October 1984, and military testing are a start in the approval process.

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APPENDIX A

SUMMARY OF CIVILIAN PILOT RESPONSES - CENTRAL, ALASKA

DOT&PF RESEARCH
OBSERVER QUESTIONNAIRE
TRITIUM LIGHT CONFIGURATION
SUMMARY OF PILOT RESPONSES

1. At what distance from airport did you first acquire lights? <1 Mi 1 1-2 Mi 5 2-3 Mi 9 3-4 Mi 10 >4 Mi 2
2. At what distance from airport did you have adequate definition for horizontal alignment? <1 Mi 1 1-2 Mi 18 >2 5
3. At what distance from airport did you have total definition on all lights (threshold & edge)? <1 Mi 6 1-2 Mi 15
>2 Mi 6
4. In the traffic pattern, were you able to maintain reference to the runway? Yes 23 No 3 Maybe 1
5. Did the down-wind corner markers help in maintaining reference while in the traffic pattern? Yes 23 No 1 Maybe 3
6. Was the wind direction indicator adequate? Yes 2 No 23 Maybe 1
Comments

Ambient Lighting Conditions: Moonlit: Yes 3 No 9 Twilight or day 13
Cloud Cover: Thin/scattered 13 Broken 1 Overcast 8
Ceiling Height AGL Precipitation: Snow 7 Fog 1 Haze 2 None 13

A.1

Name: _____
Date: _____
Aircraft: _____
Location: _____
Contact phone: _____

DOT&PF RESEARCH
OBSERVER QUESTIONNAIRE
TRITIUM LIGHT CONFIGURATION
SUMMARY OF PASSENGER RESPONSES

Return to:
Leroy Leonard
DOT&PF Research
2310 Peger Road
Fairbanks, AK 99701

1. At what distance from airport did you first acquire lights? 1-2 Mi 5 2-3 Mi 2 >3 Mi _____
2. At what distance from airport did you have adequate definition for horizontal alignment? <1 Mi 2 1-2 Mi 6 >2 1
3. At what distance from airport did you have total definition on all lights (threshold & edge)? <1 Mi 2 1-2 Mi 7
4. In the traffic pattern, were you able to maintain reference to the runway? Yes 3 No 1 Maybe _____
5. Did the down-wind corner markers help in maintaining reference while in the traffic pattern? Yes 4 No 5 Maybe _____
6. Was the wind direction indicator adequate? Yes _____ No 11 Maybe _____

Comments

Ambient Lighting Conditions: Moonlit: Yes _____ No _____ Twilight or day _____
Cloud Cover: Thin/scattered _____ Broken _____ Overcast _____
Ceiling Height _____ AGL Precipitation: Snow _____ Fog _____ Haze _____ None _____

APPENDIX B

NEW YEAR'S EVE 1983 EVACUATION CORRESPONDENCE

Oakeservices

Central, Alaska 99730

PO Box 9

1/4/84

Acting Commissioner Glenn Glenzer
DOTPF
Pouch Z
Juneau, AK 99811

Dear Mr. Glenzer:

As you are aware, the runway here at Central is the site of the experiment this winter of the tritium vapor lights. As a rural community, we are watching this experiment with interest, for we can really appreciate what its success can mean to a bush area.

On New Year's Eve, we had occasion to see first-hand how helpful the lights were. An evening fire destroyed the home of Anders Bergssen (who, by the way, is a retired DOTPF employee). In attempts to control the fire, Mr. Bergssen was painfully burned on his hands, head and back. Due to the nature of the injuries and the fear that he might go into deep shock, we requested a Medivac evacuation to get him to Fairbanks and medical attention. Conditions were only fair between Fairbanks and Central, but Medivac attempted the flight and were successful in getting the patient to Fairbanks. It was a good feeling to be able to tell them that the runway had the tritium vapor lights--and to know, in case they were unable to get over the mountains from Fairbanks, that we had an alternative in case it would be necessary for one of the local pilots or air services to try the flight from here, that an adequately lighted runway was available.

As communities like Central and Circle Hot Springs do not have available the more extensive local clinic facilities that many Native villages in the bush have, the importance of a lighted runway for emergency medical evacuations often becomes a prime factor. As you can imagine, many folks here at Central hope the experiment becomes a permanent part of our local runway.

Sincerely yours,

Miss Patricia Oakes

cc: Larry Sweet

B.1

CONSULTANT SERVICES:

Rural Educational Planning, Curriculum & Instruction
Alaska History Research & Review

GENERAL SERVICES:

Research, Editing & Public Relations
Mobile Secretarial Service - Notary Public

MEMORANDUM

State of Alaska

TO: Glen Glenzer, Acting Commissioner
Department of Transportation

DATE: February 2, 1984

FILE NO:

TELEPHONE NO: 465-3030

FROM: *Robert London Smith*
Robert London Smith, Commissioner
Department of Health and Social Services

SUBJECT: Tritium Lights at Airfields

Attached, for your information, is a letter from Dr. David Lam, Senior Flight Surgeon with the U.S. Army Medical Department at Ft. Wainwright. Dr. Lam says he is extremely impressed with the tritium lights which have been placed at the airfield in Central, and he suggests that this project be expanded to small, isolated airfields throughout the state.

Our State Emergency Medical Services plan calls for emergency lighting for runways in small villages to facilitate medical evacuations during periods of darkness, and perhaps tritium lights can provide a viable solution to this problem.

You may want to contact Dr. Lam to further discuss this matter.

cc: Governor William Sheffield

RECEIVED
FEB 03 1984

NORTHERN REGION	
Deputy Commissioner	
D & C Director	
✓ Planning Director	
Admin. Serv. Director	
Interior IA & O Director	
Western District Director	
So. Central Dist. Director	
Fbks. Intern'l Airport Dir.	
<i>Robert London Smith</i>	
RETURN	

DOT/PF
COMMISSIONER'S OFFICE

OFFICE OF THE
ATTORNEY GENERAL

02-0014 03:28

DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY MEDICAL DEPARTMENT ACTIVITY (ALASKA)
FORT WAINWRIGHT, ALASKA 99703

January 20, 1984

REPLY TO
ATTENTION OF:

Office of the Commander

Mark Johnson
EMS Coordinator
State of Alaska
Department of Health and Social Services
Pouch H-06C
Juneau, Alaska 99811

Dear Mark:

I greatly appreciate your offer to attempt to obtain funding for my trip to Anchorage on Wednesday to attend the State Medevac Task Force Meeting. As I said, normally I will be able to combine those trips with some of the other many duties that I have in Anchorage and therefore am normally able to utilize military aircraft for transportation, but in this case I was unable to. The total cost as depicted on the Travel Authorization Form attached was one hundred and fifty two dollars. If you can help me out in this respect, it would be much appreciated.

In general terms, as regards the air ambulance regulations, I like and concur with the recommendation made by John Hall that we include four specific levels of certification; one to be an advanced life support carrier (the so-called flying intensive care unit), one a basic life support carrier which could be staffed and equipped at a lower level of expertise, one general authorization for any of the major air carriers who may have to carry a patient so long as the patient's transport is arranged and coordinated through either the airlines medical department or private physicians knowledgeable in air evacuation requirements, and the fourth should be a specific authorization to use any type of aircraft whether or not it is ambulance-equipped in an emergency.

Additionally just for your information, I would appreciate it if you would mention it to anyone you know in the Department of Transportation that the tritium lights that they have placed at the airfield at Central, Alaska for field markings are extremely effective. On New Years Eve I had the opportunity to fly up there in a blinding snow storm to pick up a civilian who had gotten burned. The lights were visible for a significant period of time before we reached the field and they were of great benefit to us in landing. I would love to see this project expanded throughout the entire state to all of the small isolated fields.

I am still checking on the cost and availability of the air evacuation liquid oxygen device and the on-board oxygen generating system which we have mentioned at the last couple of meetings. When I get more information from the Air Force I will certainly keep you informed.

Office of the Commander

January 20, 1984

Just for your information I did send into Governor Sheffield several months ago an application for appointment to the Advisory Committee on Emergency Medical Services. To date I have not yet heard whether the application has been accepted but I'm still hoping to be with you at the next meeting.

Thanks again for all of your help. I am certainly enjoying working with you on this project.

Sincerely,

A handwritten signature in cursive script that reads "David M. Lam".

David M. Lam, M.O.
Lieutenant Colonel, Medical Corps,
Senior Flight Surgeon
Commanding

DEPARTMENT OF THE ARMY
222D AVIATION BATTALION (CBT)
FORT WAINWRIGHT, ALASKA 99703
January 18, 1984

REPLY TO
ATTENTION OF:

283d Medical Detachment

Mr. Leroy Leonard
DOT/PF Research
2301 Pagar Road
Fairbanks, Alaska 99701

RECEIVED
JAN 21 1984
DOT/PF RESEARCH SECTION

Dear Mr. Leonard:

I read Everett Long's recent article in the news miner pertaining to Radio Luminescent (R-L) Lights at Central. My comments will begin with answers to the questions posed at the end of his article.

Pilots name is MAJ John N. McNair. The aircraft used was a UH-1V air ambulance helicopter. Weather during the approach to Central was ceiling none, visibility 2 miles with haze, night. I approached the airport from the southwest at approximately 6000 msl. The first light I saw was the strobe on a maintenance shed. It could be seen before even the outline of the village. The runway lights were clearly visible from about 2 miles out. On a clearer night they possibly could have been seen from a greater distance. Runway reference was not a problem in the landing pattern. Except for the green color, the lights were as good as any low intensity runway lights. I did not note the wind toe or corner markings during my operations there. In addition, the runway was covered with about six inches of fresh, powdery snow. I landed short of the location of the vehicles which were meeting us and Skied up the runway in a snow cloud between the lights. The R-L lights served as excellent markers for taxiing in the blowing snow conditions.

It is my opinion that these R-L lights are a godsend to a small landing strip. The ambient light level in the night I went to central was nil. The landing at the strip was certainly much safer because of the presence of the R-L lights. I suggest that these lights be installed at all village landing strips. Certainly if they save a few lives from landing short accidents or running off the runway, they would be worth the expense. My hat is off to the fellow who came up with them.

If you have any further questions about my flight to central please call me at 353-6292.

Sincerely,

JOHN N. MCNAIR
MAJ, MSC
Commanding

APPENDIX C

PHOTOGRAPHIC EVALUATION ACTION PLAN

STATE OF ALASKA

DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

DIVISION OF PLANNING AND PROGRAMMING
RESEARCH SECTION

Bill Sheffield, Governor

2301 Peger Road
Fairbanks, Alaska 99701-6394
Phone: (907) 479-2241

April 19, 1984

Mr. Bill Remini
Program Manager
ByProduct Utilization
Office of Defense Waste &
ByProduct Management
U. S. Department of Energy
Washington, D.C. 20545

Dear Bill:

Attached is the action plan for collecting photographic data which we have previously discussed. I'm sure there will be several modifications to this plan due to limitations in the field, but I think the basics of the plan can be successfully executed. Please let me know if anyone has any questions.

Sincerely,

Lee Leonard
Facilities Research Manager

emc

Attachment

cc: D. Brown, Oak Ridge National Laboratory, Oak Ridge, TN
L. Everett, Lt. Col., NC-ARNG, Morrisville, NC
✓ K. Haff, Oak Ridge National Laboratory, Oak Ridge, TN
T. Hardy, Headquarters, AFESC/RDLS, Tyndall AFB, FL
G. Jensen, Battelle Pacific Northwest Laboratory, Richland, WA

PHOTOMETRIC DATA COLLECTION
ACTION PLAN

PLACE: U. S. Department of Energy Hanford Reservation, Hanford, WA.

TIME: April 28, 1984 - May 7, 1984

ORGANIZATION:

The field crew will rendezvous at Pacific Northwest Laboratory (PNL) on April 27, 1984. The late afternoon will be devoted to meetings and briefings by PNL staff regarding the physical terrain and the logistics of the field work. Saturday and Sunday, April 28 and 29, will be spent preparing field sites for deployment. Some of the micro data (see below) may be gathered on April 29. On Monday, April 30, the Moon will be new and deployment of lights for Macro data collection will begin and will continue on succeeding nights until the complete data inventory is collected. It is anticipated that all of the necessary data can be obtained by May 6.

PERSONNEL:

The following individuals have expressed interest in participating in this exercise and will make up the field crew:

1. Andy Thompkins - Oak Ridge National Laboratory
2. George Jensen - Pacific Northwest Laboratory
3. Bob Moles - Pacific Northwest Laboratory
4. Lee Leonard - Alaska Dept. of Transportation and Public Facilities
5. Janet Strid - Alaska Dept. of Transportation and Public Facilities
6. Technicians from Pacific Northwest Laboratory
7. Photographic Staff

This list is not intended to exclude anybody. Any TWG members are welcome and encouraged to participate, however, for planning purposes the above list has expressed their specific intention to attend as of this date.

DATA TO BE COLLECTED

MICRO DATA:

Single RL light units (wands and panels) will be compared to calibrated light sources at various distances using still photography in 35 mm, 2 1/4 x 2 1/4, and 4 x 5 formats. These data will be used for reference, calibration of macro photographic data and for the quantitative comparison to produce a computer simulation of a RL system. Micro data will be gathered each night of observation as a calibration check on each night's photography.

MACRO DATA:

The macro data to be collected will consist of still photographs taken of various RL airfield lighting configurations. Using the natural terrain and elevation changes available on the Hanford reservation to produce a vantage point. Three data sets per configuration will be collected simulating the reference required when operating VFR night within the runway environment. These are:

1. Downwind leg path.
2. Base leg turning point.
3. Final approach path.

Proposed observation paths for the simulation are shown in Figure 1. Location of distinct observation points along each of the three paths are specified in the table. The specific locations of these points has been determined to encompass a data set which will best relate to the critical

visual keys required by pilots using an RL system. Observations along the final approach path will include observations of various VASI configurations. In all cases the 12" x 12" RL unit panels will be used as edge lights on 400 ft. spacing. The inventory of runway end markers, VASI's, and lead-in light configurations which we intend to photograph is shown in Figure 2. The total data set will include about 100 photographs. However, since a number of exposure settings and formats are desirable perhaps 300 to 600 photographs will be collected.

TABLE 1
Photographic Simulation Data Set

Point	Observation Path	Distance From Threshold in Miles	Altitude in Feet	Route Speed in Knots	Viewing Orientation
1	Downwind	.25	500	70
2	Downwind	.5	600	85	
3	Downwind	.75	600	100	
4	Downwind	1.0	900	110	
5	Downwind	1.5	1000	130	
6	Downwind	2.0	1000	150	
7	Base	0.5	150
8	Base	1.0	300		
9	Base	1.5	500		
10	Base	2.25	600		
11	Base	3.25	800		
12	Base	4.125	1000		
13	Final	0.25	70
14	Final	0.5	140		
15	Final	0.75	200		
16	Final	1.25	350		
17	Final	1.75	500		
18	Final	2.5	700		
19	Final	3.25	1000		
20	Final	4.0	1000

Figure 1: Data Point Diagram

FIGURE 2

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<p>2 L. E. Leonard State of Alaska DOT&PF 2361 Peger Road Fairbanks, AK 99708</p> <p>L. Hegdal State of Alaska DOT&PF 2361 Peger Road Fairbanks, AK 99708</p> <p>W. C. Remini R&D and Byproducts U.S. Department of Energy Washington, DC 20545</p> <p>J. J. Jicha, Jr. R&D and Byproducts U.S. Department of Energy Washington, DC 20545</p> <p>30 DOE Technical Information Center</p> <p>K. W. Haff P.O. Box X Oak Ridge National Laboratory Oak Ridge, TN 37830</p> <p>E. Lamb P.O. Box X Oak Ridge National Laboratory Oak Ridge, TN 37830</p>	<p>4 <u>DOE Richland Operations Office</u></p> <p>M. Dayani H. E. Ransom J. L. Rhoades J. D. White</p> <p>2 <u>Battelle-Alaska Operations</u></p> <p>L. D. Perrigo</p> <p>40 <u>Pacific Northwest Laboratory</u></p> <p>S. K. Edler C. R. Hann P. E. Hart J. H. Jarrett G. A. Jensen (26) J. L. McElroy A. M. Platt G. L. Tingey Publishing Coordination (2) Technical Information (5)</p>
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