Temporary Worksites

Fire Control, Security & Rescue for Frontier Workcamps

A unique application of safety measures and controls

By Doug Avin

WHETHER FOR GOLD MINING operations in Indonesia, pipeline projects in Venezuela, or diamond mines in Angola, wilderness workcamps are an essential component of frontier operations. Base camps are the essential springboard of operations for the harvesting of natural resources and civil development projects in frontier regions.

Many developing nations have turned to the harvesting of naturally occurring resources as a source of income for civil development projects that will elevate the nation from an agrarian economy to industrialized status. This exploitation includes the development of petrochemical energy reserves, mining for valuable minerals and forestry operations. Once sources of funding for these projects are secured, interest shifts toward the need for infrastructure development, such as hydroelectrical dams, permanent roadways and train railways. Some nations have such an abundance of natural resources that long-term managed harvesting is a primary sector of their gross national products and a principal trade commodity.

All such activities require a base of operations to be established in an undeveloped frontier area from which to support such industrial processes. Frontier base camps typically face the same essential scope of hazards as urban industrial sites—such as bulk fuel depot, high-pressure gas cylinders, toxics and other hazardous materials—as well as specialized hazards such as marine and/or aviation operations, but lack the typical control and mitigation resources available at urban sites. Frontier theaters present a unique combination of factors that emphasize the criticality of safety-driven design in order to minimize incident probability and control risk.

- **Isolation.** External assistance is generally nonexistent. Firefighting, security, technical rescue and medical response are virtually dependent on site-based capabilities.
- **Limited on-site firefighting capabilities.** Firefighting water supplies will typically be minimal (if present at all), as construction of "typical" urban-type water distribution systems will be logistically impractical and economically infeasible.
- **Lack of fixed fire-extinguishing systems.** These are usually absent due to minimal infrastructure and the "temporary" nature of structures.
- **Less-fire-resistant building materials.** In most cases, structures will be of lightweight construction, somewhat "temporary" in nature; as such, they may utilize a large percentage of "field expedient" materials. Tents and other membrane and film-type structures are also common, while masonry is less common, as the emphasis is on utility and light, modular construction.
- **Wildfire considerations.** Incoming fires from the bush are a concern, as is escape of structural fires from within the camp compound.

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•**Terminal management of hazardous wastes.** In most cases, no system is available to transport flammables, toxics and septic wastes off-site for remote treatment, disposal or storage.

•**Integration of residential housing with industrial areas.** Frontier camps are basically self-sufficient entities that necessarily incorporate man-camp support operations as well as industrial operations.

•**Low-intensity warfare.** Many developing countries are in a state of political flux due to civil wars and separatist movements, guerrilla warfare and terrorism.

Because response capability is inherently restricted, minimizing incident potential—in terms of both probability and magnitude—is a fundamental parameter of site design. It is much more practical and cost-effective to reduce risk in the design stage, rather than to increase expenditures for extra personnel, training and equipment to deal with hazards that could have been diminished or eliminated in the initial planning stages. Industrial sites typically embody many hazards due to the requirements implied by the scope of a project, but these risks can be significantly reduced through coordinated design. This is accomplished by orchestrating primary safety engineering imperatives to optimize resources, buffer hazards, reduce vulnerability and otherwise limit risk given the proposed site and project scope.

Frontier base camps typically face the same essential scope of hazards as urban industrial sites.

While essential elements of safety engineering—such as separation distances, zoning and spatial orientation—can be considered prior to reconnaissance, the actual on-the-ground survey is the catalyst that produces the final product. All possible data of site topography should be gathered prior to the ground survey. Satellite photos may be available from various sources, although most government satellites are tasked for defensive purposes and resulting information may be classified (as many frontier areas are located in regions where guerrilla activity is common). Hand-held global positioning systems are a useful tool, but they cannot produce the high-grade "military type" maps with eight-digit grid coordinates for navigation.

Survey teams identifying potential campsites should assess the site from various perspectives.

•**Security.** Must be able to secure the campsite and surrounding perimeter and defend against aggressors. Security is fundamental and all other considerations are secondary.

•**Topography and slope.** Camps either address erosion control or suffer from the lack of it. For example, the Trans-Amazon Highway project in Brazil identified the critical need for erosion control to be part of camp siting and design.

•**Vegetation.** This encompasses various factors such as biomass and living-vs.-dead ratios, natural firebreaks and safe retreat areas.

•**Aviation and marine operations.** Key factors to consider include microclimate, prevailing winds and flat areas for potential fixed-wing runways.

•**Disease vectors and reservoirs.** Camps should not be "located within 200 feet of swamps, pools, sinkholes or other surface collections of water unless such quiescent water surfaces can be subjected to mosquito control measures" (OSHA 428). It is virtually axiomatic that disease and nonbattle injuries outnumber battle casualties approximately 5:1 even in full-on war. The management of human waste is an essential (and urgent) consideration.

Camp Design & Layout

Separation Distances

Separation distances play a key role in minimizing fire incident size at frontier sites. As firefighting resources will likely be limited, appropriate distances help contain incidents and prevent expansion both within the compound and into the undeveloped natural environment beyond the settlement. Layout is invariably a compromise between the convenience, utility and economy of "cluster developments" (the close aggregation of structure siting) and the competing demands of safety imperatives for minimum distances.

Cluster formations minimize material requirements for utility distribution systems, reduce labor required for clearing land and minimize the structural footprint, thereby reducing encroachment on the adjacent natural environment. "Zone clustering"—the next organizational level of urban planning—for normal residential developments allows "greater freedom of design of increasing overall densities without the loss of essential amenities" (Schwarz, et al).

However, the set of assumptions on which the advantage of cluster developments is based is not the same for base camps in remote wilderness areas. The conventional advantages of cluster designs are based on the significant assumption that all other safety considerations are equal. Principally, this means that residential protection will not be degraded by the clustering scheme (including road access for firefighting vehicles, sufficient utility distribution of water for firefighting purposes, etc.). Furthermore, the potential advantage of cluster developments does not assume the incorporation of industrial areas within residential sites of habitation, a characteristic of frontier settlements. Therefore, in remote base camp design, the more-conservative industrial approach, with generous margins, access for firefighting, evacuation and containment, is indicated.

Separation distances for fire control are determined according to "occupancy classification" and the potential for fire posed by, or vulnerability of, the occupancy in question. Hazard assessment and subsequent classification must factor occupant load density, materials stored in bulk (e.g., fuel), building materials used to construct the structure (rate of fire spread, toxic fume production, evacuation timeframes); activities and processes (sources of ignition); and any other factors influencing fire safety and risk control. In relative terms, highly protected properties will have shorter separation distances, while "primitive" or high-risk occupancies will have greater separation distances.

Most codes allow different types of hazards with similar threat levels to be positioned in close proximity provided special precautions are followed and long separation distances to human habitation are maintained. For example, both the 1997 Uniform Fire Code (7902.2.3.3) and the 2000 International Fire Code (3404.2.9.5.3) call for the separation of diked liquid fuel containers from LP-gas containers to be 10 feet from the centerline of the diking around the liquids. This is to prevent leaking liquid fuels from pooling beneath the LP-gas containers. These regulatory allowances are based on the premise that even if property damage is accentuated by the chain reaction of closely placed high-risk hazards, adequate separation from human habitation will reduce the probability of loss of human life. Close juxtaposition of high-risk hazards also addresses the logistical realities of space limitations and utility of service, and allows site designers to create generalized areas of similar risk.

Siting distances proposed by the various fire codes are minimums that can be expanded at the site designer's discretion until deemed excessive and impractical. The final separation distance determination of each cache and the size limits of the caches themselves should take into consideration the unique nature of frontier camps (limited resources and limited firefighting capability). Thus, frontier sites should emphasize gains in fire control received from expanded separation distances in direct proportion to their limitations in firefighting capability.

In the case of frontier environments, the distinct concepts of "maximum-possible-fire" and "maximum-probable-fire" converge to varying degrees—not from failure of resources, but the simple absence of them. Therefore, the true level of firefighting capability must be determined. If fires could easily get out of control and will have to burn themselves out, a premium on separation distances is needed to prevent total camp (or camp and surrounding environment) conflagration.

With regard to distances of separation between camp features and the surrounding undeveloped natural environment, every attempt should be made to reduce excessive land-clearing in order to reduce environmental impact. In addition, economics and logistics will logically limit spread beyond practical boundaries (provided selective clearance is practiced). Minimum separation distances will be a much-more-critical consideration than the loss of a few more feet of forest or jungle—especially in light of the potential for a much greater loss from a runaway fire in the compound spreading into the surrounding environment. Environmental impact is inevitable even with the most-minimal presence. "Many studies have found that the loss of vegetation cover on lightly used sites is nearly as substantial as the loss on heavily used sites" (Hammitt). Ecological preservation of remote frontier environments hosting base camps is a matter of degree and must be examined from macro as well as micro perspectives.

Zoning & Spatial Orientation

While the concept of separation distances corresponding to degree of hazard or occupancy focuses on the characteristics of the individual units, the next level of fire control engineering, zoning and spatial orientation considers the relationships and interaction of those units within the camp as one entity. Once separation radiuses have been determined, the orientation of features should further diminish hazards and enhance fire safety.

Most internationally recognized fire safety codes require similar separation distances for the various features found at industrial sites; the [relative] uniformity of feature treatment can allow designers to categorize different features according to similarity of hazard class, separation distances, etc. Grouping features according to characteristics and threat levels allows a "packing" or "concentration" in order to segregate high-risk hazards from general occupancies of high-population density and areas of routine human habitation. This next level of categorization can by used to lay out cascading zones of increasing/decreasing threat level—from general class, to flammable, to explosive, etc. Such a system both maximizes safety and minimizes site footprint, integrating all the necessary features in the closest orientation shown to be at "safe" (and practical) distance.

A tiered system provides a threat-level zone gradient that can separate life safety vulnerabilities from inherent hazards in an efficient and practical way, elevating a camp layout from the level of a jumbled hodgepodge that meets separation distance requirements, but is costly, illogical and inefficient. Ideally, the layout would locate high-population density and low-risk occupancies upwind of bulk hazard storage sites and industrialized areas (and waste treatment and livestock), and separate the two general classes by adequate distances. A clear, visually apparent demarcation between "safe" and "increasingly hazardous" areas would exist; and evacuation routes would be obvious and simplified. In reality, much of the stored hazardous materials, such as liquid fuels, will eventually be distributed throughout the camp for end-user utilization. Protocol can help prevent end-user sites from becoming intermediate storage caches.

Traffic, both for firefighting access and evacuation egress, will be complicated by the dispersed storage of high-risk hazards such as large volumes of liquid fuels. However, when such hazards are unavoidable due to circumstance or the advantage it conveys, protocol can reduce the probability and magnitude of emergency incidents.

Topographical Parameters

As the ability to perform major earthmoving, grading and similar functions may be minimal or nonexistent at many remote projects, the topography of the proposed site may present the essential opportunities and limitations that will have to be utilized and accommodated. The existing lay of the land will present obvious lanes of foot traffic, the availability of relatively flat areas suitable for structures, margins from watersheds, possibility of fixed wing aircraft runways, and topographically defined sources of ignition such as marine and aviation operations. The confirmation, contours and erosion of the surface may also indicate typical hydrological cycles that must be considered

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(e.g., for bulk fuel containers located within flood plains. Monsoon or wet seasons can cause creeks and waterways to rise dramatically. Riverine locations are especially prone to erosion. All sloped areas should be examined for degree of naturally occurring erosion and the potential for erosion on steep slopes assessed. Trail hardening should be considered for any installation as well. "Gullying caused by trail erosion will soon develop on trails that climb long steep gradients" (Proudman and Rajala 19).

Both rock outcroppings and heavy forest (to a lesser degree) may attenuate explosion concussion and blast wave, with the forest allowing emergency egress; outcroppings may obstruct evacuation. Whether for industrial or military purposes, detonation of high explosives creates a high-pressure wavefront emanating from the energy source, sometimes followed by a relatively low-pressure interval as the atmosphere is forced outward by the blast wave. The 2000 International Fire Code (3302.1) defines the criteria for a natural explosion barricade providing baseline blast shielding as "natural features of the ground, such as hills, or timber of sufficient density that the surrounding exposures that require protection cannot be seen from the magazine or building containing explosives when the trees are bare of leaves."

"Safe" retreat areas of barren ground or bodies of water should be identified. Broken areas or discontinuities in surrounding vegetation should be identified for the possibility of backfiring purposes. These natural firebreaks may present areas that can be utilized for backfiring in opposition of an incoming front. Areas with potential for accelerated spread velocity during upward wildfire advances (such as preheating of slopes) should be noted as well. Structures sited on ridgetops will be difficult for firefighters to approach and the proximity of aviation areas with high-density occupancies makes ridgetop structures more vulnerable to low-flying aircraft. Therefore, the designer must note the probable lanes of approach and flyovers.

Site Vegetation

Site vegetation is most practically considered as 1) the initial complement existing at project inception; and 2) the subsequent landscape management condition. Alteration of the vegetation community is inevitable, from land-clearing to removal of dead fuel loads of windfall (resulting from natural eco-mechanisms) and slash resulting from land-clearing activities. Since environmental durability may be low, it is much more practical and efficient to contain the camp, rather than try to maintain small untouched islands of botanical preserves within the compound. "Project development should not be delayed through implementation of overly stringent standards, or the requirement of an environmental impact assessment on each site. The approach should be matter-of-fact, relying on a sound information base for decision making. The exercise should ensure that avoidable and irreversible damage to the environment be prevented, contained or in some way mitigated. This may be achieved by siting choices, through establishing appropriate camp establishment, zoning, management and closure plans and/or through preparing appropriate site reclamation programs" (UNEP). Thus, it is advantageous—from fire safety and environmental perspectives—to assume stewardship for the management, control and cultivation of the site vegetation, both within the compound and in the surrounding forest margin.

"Fuels can be described by their loadings (both live and dead fuels), heights, depths, continuity, vegetation species and location" (Hamilton, et al 7). While slash and windfall are essential elements of a healthy natural environment, the environmental impact of the loss of habitat due to their removal will be minor compared to the impact from wildfire within the camp spreading through dead brush within the camp and into the surrounding forest. Work assignment and project priorities should include prescribed burning to reduce dead fuel loads and brush piles created by construction.

Vegetation utilized for erosion control around structures should emphasize turf and spreading ground cover as a way of minimizing fuel and allowing accessibility. Wildfire spread in the canopy can link areas even when ground fuels are minimized. Lay-down yards for timber harvested in the process of land-clearing should be located so that when the first phase of land clearance is completed, adequate distance will separate the lumber pile from the adjacent forest.

Microclimate

Microclimate encompasses those natural features of the local environment that can impact camp operations and are more specific to the unique setting of the camp rather than general or regional weather patterns. This includes relatively constant phenomena such as prevailing wind currents, periodic events such as tidal effects, or seasonal effects such as smoke pall from prescribed burning associated with agricultural cycles or monsoon.

Microclimate will influence both the siting of habitation enclaves and aviation operations. Runways should be oriented with the prevailing wind; the balance between topography and wind will present the best option for placement. Occupancies of lodging, medical care, food preparation and similar functions should be located away from the axis of fixed-wing runways due to the potential for overshoot and undershoot. This principle also applies to natural approach paths for helicopter landing zones and flyover escape paths for both fixed and rotary wing aircraft where hot "mayday" landings are more likely to occur.

Winds will channel through land contours in predictable ways. This knowledge, as part of the site-specific wind model identifying the prevailing wind, can be used to locate features with regard to upwind/downwind orientations. For example, fire hazards such as bulk fuels, toxicity hazards (pesticides and water purification chemicals) and septic hazards (landfills, sewage treatment and livestock) should be oriented downwind from lodging, dining and labs for both safety and aesthetic reasons. The likelihood of probable fire spread direction, as indicated by the microclimate, and the subsequent orientation of industrialized areas downwind will minimize the probability of spread to populated areas and will channel smoke and toxic fumes/gas away from human enclaves. Prevailing winds and probability of fireline advancement on sites should be examined as well. In some areas, the environment may experience daily rainstorms during monsoon season. Such rainfall can depress the spread of wildfire and limit the range and duration required for fires that must burn themselves out.

Bulk Fuels & Electricity Distribution

Energy is an essential requirement of all contemporary frontier operations of extended duration. Due to the isolated nature of these worksites, this usually requires on-site generation of electricity and the use of fuels (liquids, gases and liquefied gases). Contemporary operations also require electricity for powering high-performance technology (radios, lighting, computers). Solar power and other "earth-friendly" energy applications have been used successfully, but most wilderness workcamps utilize electricity from hydrocarbon-fueled generators. Refrigeration can also be accomplished via LP-gas. Liquid fuels and low-pressure liquefied gases are the predominant type of fuel available in the backcountry. Bulk fuels must be handled and stored with care to avoid conflagration. Again, separation distances between bulk storage sites and human habitation should be preserved, and protocols enforced for handling—including off loading from boats and planes and during refueling operations.

Aviation fuels. The three basic types of aviation fuels are: 1) gasoline-based, known as "AVGAS"; 2) kerosene grades such as JET A, JET A-1 and JP-5/6/8; and 3) blends of gasoline and kerosene such as JET-B and JP-4. Under normal conditions ("non-crash" conditions of simple storage), JET and JP grades that incorporate kerosene are relatively less dangerous due to lower autoignition temperatures and relatively slower rate of spread. However, while large commercial and military aircraft using turbine engines utilize these grades, AVGAS is the fuel likely to be used by the smaller aircraft (with reciprocating engine power plants) primarily used to support frontier expeditions.

In addition, it must be realized that the relative advantages of the kerosene grades over AVGAS are only a factor under ambient conditions. The lower rating of kerosene-based fuel flame spread is based on tests of flame spread over still pools such as those that can occur from spillage during refueling. Under high-impact "power-on" crash conditions, all fuels tend to atomize and form a highly reactive mist. When aerosolized, the speed of flame spread will be essentially the same regardless of the liquid spilled due to more-effective mixing of the oxidizer with the fuel. This principle contributes to the effectiveness of fuel-air "daisy-cutter" bombs and can play a role in grain elevator explosions. Regardless of the type of aviation fuels present, all bulk fuel storage caches and aviation fuels should be sited away from runway undershoot and overshoot lanes.

Although both bulk fuel storage and power generation will be relatively localized, some degree of hardwire network will be needed for distribution—even if only accomplished with extension drop cords. Most small generators can power multiple devices simultaneously. The nature of frontier operations implies that these networks will be minimal and restricted to high-priority usage. Conduit may be nonexistent and the wiring "temporary" in nature. These sources of ignition—both the generation element and end-use point—should be critically assessed. Both protocol and appropriate equipment such as portable independent detection devices and fire extinguishers can significantly reduce risks.

Earth grounding should be employed at liquid refueling sites as well as in electricity distribution systems. NFPA recommends "to dissipate any charge of static electricity on the aircraft and any charge that may be generated by the flow of fuel through piping, valves, filters, hose or other components during aircraft servicing, the aircraft and all fueling vehicles, hydrants, pits, cabinets and nozzles shall be electrically bonded to each other and grounded before fuel flow starts. When servicing fixed wing aircraft at a rate of not over 25 GPM using hose of not less than 1-¼ in. nominal diameter, only bonding shall be required" (NFPA 535). Such elaborate techniques may not be practical or possible in workcamps. In the case of primitive camps or over-wing fueling, where no convenient bonding method is available, a simple protocol of touching the fuel tank cap with the dispense nozzle prior to removal of the cap, and keeping the nozzle in contact with the fill port during fueling can reduce the potential for static discharge and ignition. In addition, ground-fault-interruption switches are both lifesaving and inexpensive, although in some regions they may be difficult to obtain locally.

Adjacent Hazards

Because stationary adjacent hazards, both upwind and upstream, can threaten a site, their risk should be assessed—from past activities, to proposed or potential future activities. Influential sites of past activity or industrialization should be investigated via an on-ground survey if possible. A frontier operation will face the same challenges of isolation with regard to terminal waste disposal. Many industrialized activities create significant amounts of hazardous waste. If an adjacent site is currently in operation, a great amount of potentially hazardous waste will be produced just from the operation of the camp, in addition to any industrial activity; the adjacent camp will also be a potential source of ignition for wildfire.

Mobile hazards posed by marine and aviation operations along major traffic arteries should be similarly considered. Marine operations are a concentrated form of mobile hazard. Permanent settlements for a considerable distance both upstream and downstream

Bulk fuels must be handled and stored with care to avoid conflagration. This requires sufficient separation distances between bulk storage sites and areas of human habitation.

Social/Political:

❑ Are there fire or security vulnerabilities due to nearby facilities or activities (military bases, industrial sites, large-scale slash-and-burn land clearing, churches/mosques/temples, etc.)
❑ What is the average public perception of expatriates or the camp by the indigenous natives near the camp?
❑ What are the demographics of the region in which the camp is located, and the demographics of the nearest urban site?
❑ What is the typical fire and crime profile for the area?
❑ What is the potential for social unrest?
❑ How long has the current ruling government been in power and how did it ascend to control?
❑ What is the host country's record on human rights violations?
❑ How are law and order maintained in the urban areas?

Climatic/Meteorological

❑ What foreign governmental entities are available for climatic data?
❑ Have typical dry and wet seasons been delineated?
❑ What is the typical rainfall, in inches, by month?
❑ Have "10 year," "50 year" and "100 year" events been determined for floods, storm surges, hurricanes/typhoons, etc.?
❑ During rainy seasons, are the overland roads from the camp to developed urban areas intermittently washed out, or are they vulnerable to rock or mud slides?
❑ Do roads from the camp to developed urban areas go over mountainous areas in the wintertime?
❑ What is the direction of prevailing wind and wind speed by month?
❑ What is the average humidity by month?
❑ If located with access to bodies of water, what is the typical water level, by month, in relation to the campsite?
❑ If sited at a riverine location, what is the average surface current speed and bottom type?
❑ If located on open water, what is the typical tidal phenomena?
❑ Is the site and surrounding terrain tidal marsh, desert, flat savannah, mountain forest, triple canopy jungle, etc.?
❑ Is surface type sandy, muddy, snow-covered, brush-covered, rocky?
❑ Is the terrain at the campsite prone to erosion?
❑ Are topographical maps available? How recent are they?
❑ Are satellite photos available for the region?
❑ Are offshore navigational maps available for the region?
❑ Do any seasons precipitate an increase of insects or other disease vectors from the natural environment?

Camp Perimeter

❑ Does a physical barrier such as a fence protect the perimeter of the camp? Is concertina wire or razor tape used? Is a hot-wire utilized to keep vermin out of the compound?
❑ What is the depth of the clear zone around the camp?
❑ Is debris or salvage material an impediment to movement in yard areas? Can it be used for cover or concealment? What is cover within the compound and what is only concealment?
❑ Are there lights illuminating the clear zone? Is the lighting overlapping and sufficient to illuminate a 360-degree border around the camp?
❑ Are guard towers or guard shacks present? Are they hardened?

Bulk Fuels

❑ Is the bulk fuel storage area secured?
❑ Is the bulk fuel storage site beyond the average throwing distance from the perimeter?
❑ Are physical barriers present to protect the depot from small arms fire?
❑ Are there procedures in place to minimize chances of ignition at refueling sites?
❑ Is firefighting equipment available at refueling sites?
❑ What is the proximity of structures for housing and human enclaves?
❑ Has possible blast effect been considered and are there existing physical barriers between bulk fuel storage and populated areas?
❑ Is there a contingency plan for evacuation of the installation in the event of runaway fire in the bulk storage area?
❑ What is the source of heat for the camp?
❑ Is fuel usage controlled and documented?
❑ How are fuel supply levels monitored?
❑ Are both bulk supply and portable "jerry can" supplies secured?
❑ Are other bulk hydrocarbons secured?
❑ Are firefighting resources adequate for the proposed camp at maximum work phase?
❑ Is diking indicated due to floodplains or tidal activity?

Aviation: General

❑ Are emergency procedures formalized and practiced?
❑ What firefighting appliances are in place for aircraft emergencies?
❑ What fire control measures/procedures exist for refueling operations?
❑ What plans and resources exist for attending to "mayday" landings?
❑ What means are in place for preventing the spread of fire through various aircraft zones of helicopter LZs, runways for fixed-wing aircraft, taxiways, parking areas, refueling sites, bulk fuel storage areas?
❑ Are aircraft areas secured from intrusion?
❑ Are medical teams trained in loading and unloading procedures for the routine aircraft?
❑ Where is the communications for airborne operations based?
❑ Are personnel briefed on chain-of-command for airborne operations?
❑ Are radio operators formally trained?
❑ Are signalmen formally trained?
❑ Are personnel versed in basic emergency aircraft signaling?
❑ Are all applicable personnel versed in basic emergency radio operations and communications?
❑ Are wind direction indicators in place for pilot/ground crew reference?

Rotary Wing Aviation

❑ What are the dimensions of each helicopter landing site; hard surface, cleared surface and obstruction-free surface?
❑ Is the landing surface firm enough to prevent helicopters from bogging down, or creating excessive dust resulting from rotor wash?
❑ Is the surface firm enough for a loaded helicopter to land, shut down and restart?
❑ Is the landing site surface relatively level and the slope less than 7 %?
❑ Is the average direction of landing over the lowest surrounding obstacles and generally into the wind?
❑ Has the departure route been analyzed?
❑ Are there one or more escape routes along the approach path that can be used if a "go-around" is required?
❑ Has the effect of the position of the sun relative to the approach path, and the presence of shadows on the landing site been considered?
❑ Are vertical air currents present on the approach path?
❑ Are touchdown and loading sites determined?

should be identified according to characteristics such as location, population and industrialization. Riverine operations also pose the secondary threat of sporadic campfires along the land-to-water margin from personal travel. Therefore, the volume of travel along waterways or nearby paths should be assessed and an annual baseline determined that includes factors such as dry seasons when marine travel is restricted, and increases in traffic due to festival seasons or agricultural cycles. If the host country's military is engaged in antiguerrilla operations, a riverine camp may be exposed to opposing forces as well.

Camp Operations

Marine & Aviation Operations

Remote installations require some form of efficient resupply and reinforcement. Only the most primitive and temporary camps used for survey and

Life-Safety Checklist

❑ Are instruments available for determining density altitude: altitude, temperature and humidity?
❑ Are "typical" helicopter types and their basic specs determined?
❑ Is electrical discharge gear available for cargo flights?
❑ Is day and night landing zone marking in place and understood as standard by both aviators and ground crews?

Fixed-Wing Runways

❑ Is the landing strip level and free of obstacles?
❑ Is the runway oriented so that aircraft can takeoff/land into the wind?
❑ Is the runway of minimum dimensions with respect to the types of routine aircraft, types of loads, direction and velocity of the wind, ground conditions and location of obstacles?
❑ Are taxiways provided on one or both sides of the runway?
❑ Are taxiways separated from the runway by at least two and one-half wingspans of the largest aircraft expected to land?
❑ Are the taxiways at least 1.5 times the wheelbase of the largest aircraft expected to land (minimum of 20 feet)?
❑ Are parking points separated from the active runway by a minimum of 2.5 wingspans of the largest aircraft expected to land? Do they utilize revetments?
❑ Are the parking areas located where aircraft can enter and leave the parking area without delay?
❑ Is the runway marked with day and night landing strip markers, and method understood as common by both pilots and ground crews?
❑ If the runway is marked only on one side, is the left side the marked side?

Marina

❑ Are lifesaving devices readily accessible?
❑ Are firefighting appliances readily accessible?
❑ What is the typical water depth in the anchorage by month?
❑ Does the marina experience daily tidal effects? What is the extent?
❑ Are refueling procedures formalized?
❑ What communications are available between the shore crew and inbound vessels?
❑ Are lighting and associated physical security measures adequate to provide security commensurate with the environment?
❑ Do vessels have firefighting appliances?

Support Services

❑ Are overland, airborne and/or waterborne supply routes available?
❑ What is the typical response/delivery time for critical supplies?
❑ Has provisioning flow versus marina water depth been considered?
❑ During certain seasons, do support supply routes experience inhibition due to hostile weather?
❑ Are fixed wing parachute drop zones available?
❑ What is the mask clearance ratio of the DZ?
❑ Can the ground crew communicate with aircraft and assist in determining VIRs, computing drift, etc.?

Firefighting & Security

❑ Are fire detection or smoke detection sensors used at the camp?
❑ Are there manual pull stations?
❑ How is the firefighting team trained, organized and dispatched?
❑ Do all personnel know the formal, standardized signal for fire alert?
❑ Are all areas of heightened risk clearly demarcated?
❑ If a natural reservoir of water is available for firefighting purposes, how is it utilized and what is the proven reaction time for its utilization?
❑ Are generators, pumps and hoses staged in readiness? Are the generators/pumps kept topped-off with fuel at all times?
❑ Has contingency planning been performed and have evacuation routes been determined for the various scenarios?
❑ Are guards freelance operators, supplied by a private company or soldiers in the armed forces of the host country?
❑ Do guards double as firefighters?
❑ Is each member of the guard force trained in basic first aid?
❑ Is one member of the guard force a dedicated medic or does the camp have noncombatant emergency medical personnel?
❑ Are guards multilingual?
❑ Does the guard force regularly drill with the firefighting team to provide covering security and secure the camp under emergency conditions?

Medical Rescue

❑ What is the level of on-site treatment (noninvasive, invasive, IV management, defibrillation, advanced airway management)?
❑ Is the camp drilled on chain-of-command, duties and execution of triage?
❑ What is the travel timeline duration, by season/weather, for evacuation from the base camp to advanced facilities for:
- trauma center, blood bank, burn center
- advanced surgical care, dental surgery
- decompression facility or hyperbaric medicine

❑ Has specialized training been received for emergency medicine for the higher-probability incidents?
❑ Is there a location adjacent to aviation or marine off-loading sites that is designated to function as a triage area?
❑ Is the inventory of medical supplies, search-and-rescue equipment, etc., commensurate with the actual scope of operations?
❑ Is emergency equipment in good condition?
❑ If an emergency motor vehicle exists, is it hardened for the applicable terrain (e.g., extended capacity gas tanks, four-wheel drive, radio communications, heavy-duty shocks, winch)?
❑ Will a full backboard fit into the applicable vehicles and aircraft? Can vehicles accommodate attending medics, jump kits, O_2 cylinders, advanced care systems?
❑ Does the med-lab have refrigeration?
❑ How are drugs stored, dispensed, documented?
❑ Is the med-lab area a secure area?
❑ Is emergency medical support available 24/7?
❑ Can cylinder storage be accomplished safely in all anticipated areas?
❑ What secondary maritime and aviation contractors are available on an emergency basis for evacuation response?
❑ Are medical personnel conversant in medical terminology in the host country language and able to transmit and receive directions from remote physicians over radio hook-up?
❑ Can applicable venom serums be secured?
❑ Have prominent jungle/tropical medicine considerations, including parasites, been considered and prepared for?
❑ What are the local sources for medical grade gas?
❑ What veterinarian medicines are available in the region?

reconnaissance will exist without some form of marine/riverine operations, aviation operations or both. While overfly zones for aircraft may be liberal, acceptable landing zones, especially for fixed-wing aircraft, can be restricted in mountainous or forested areas. When fixed-wing airstrips are at a premium, the potential for military landings should be considered (in partner with the host country). Relief efforts may require significant aviation capability in order to address problems effectively. The potential for seasonal problems such as floods or acute problems such as refugee exodus and migration in border areas should be considered. In some cases, private workcamp runways may be appropriated by martial law or sovereign privilege in order to support relief efforts or military offensives.

Space limitations at some urban airport locations prompt the use of barriers at the ends of runways to protect adjacent areas from overshoot (and to provide noise attenuation). While runways cannot be utilized by fixed-wing aircraft until they are cleared along the entire distance of the minimum length (determined by the particular aircraft and including ground-to-air mask clearance), locating permanent brush piles or cargo lay-down yards at the ends of runways should be avoided on the frontier if possible.

The countryside around fixed-wing runways and heliports should be reconnoitered for discontinuities in vegetation that could be utilized as firebreaks should an aircraft undershoot or overshoot. Aircraft crash sites may not necessarily be on the designated runway, so backfiring areas or firelines should be identified should an aircraft crash in heavily wooded areas located some distance from the camp. Backfiring may be necessary to restrict crash-related wildfires from expanding into the countryside or advancing on the camp. The impact of prevailing winds—considered when designing runways and heliports—should be considered when examining possible firebreaks and the potential for prevailing winds driving the spread of the fire in particular directions.

Integration of Fire Control & Security Parameters

The exploration and exploitation of the wilderness in the developing world is inherently intertwined with heightened security requirements; therefore, the disciplines of firefighting and security should be an integrated system on the frontier. Many projects, such as petrochemical projects in Peru and Indonesia, have significant security forces. In some regions, such as mining operations in Angola, workcamps endure routine attacks by armed guerrilla forces—and regularly suffer casualties as a result. Aggressive forces find it easy to procure and use heavy weapons such as crew-served machine guns and anti-armor rocketry as well as landmining roads. In addition to kidnapping raids (common in regions such as Columbia and the Philippines), camps are often seized, resulting in the torture and death of many inhabitants.

By definition, developing regions are in a state of political and civil flux. Such regions are often unstable and suffer from land disputes with aboriginal peoples, separatist movements, breakaway republics and civil war, social upheaval, renegade gangs of bandits or armed guerrilla forces. Small terrorist groups are especially common when governmental regimes breakdown into localized factions ruled by tribal warlords (as seen recently in Somalia). Even when a host country officially sanctions a project, expeditionary teams in remote backcountry regions operate primarily as an autonomous, independent entity. Some security teams are essentially waging full-out guerrilla warfare where the camp is besieged by hostile forces with heavy weapons, while the security team cannot use commensurate weaponry due to restrictions enforced by host governments. In such situations, the security team is essentially outgunned, making the optimization of security via camp design (which includes defense preparations and escape and evasion planning) and the fire control strategy of paramount importance.

Designing for Security Parameters & Fire-Control

The degree of target hardening that a frontier base camp should have depends on the specific environment. Many basic security gains can be realized via design that complements the fire-control plan. Many critical aspects of enhancing security are low-cost strategic measures realized by efficient design that addresses fire-control imperatives. Optimized camp layout accommodates physical security and hardening against aggressor forces as much as possible, even if the current threat level is considered low. Security measures typically reinforce fire-control measures.

Separation distances can provide a dual benefit in this regard. A significant "clear margin" gives a forest setback for fire control and establishes a security control zone that can be hardened. It is best to push the forest back an extra measure in order to gain a considerable firebreak, reduce ground-to-air masking of aircraft and establish an effective security zone around the camp. Separation distances and spatial orientation of fire hazards can delineate natural security perimeters as well, and help inhabitants define avenues of escape, cover versus concealment and opportunities for target hardening, and conduct small unit tactical drills for the given layout and terrain.

Adequate separation distance from hand-thrown incendiary devices (such as Molotov cocktails) is typically possible in frontier theaters, but separation from small arms fire by distance alone is virtually unattainable; this requires bunkering or target hardening. Even light assault weapons can hit large targets at 1,000 yards; heavy machine guns can typically provide flatline, grazing fire at 1,000 yards (U.S. Army 1+). Thus, wherever "concealment" is not sufficient to meet the threat level and true cover must established, any shielding mechanism should be sufficiently rigorous to meet the challenge. Structure "bullet resistance" is defined by the 2000 International Fire Code (3302) as "constructed so as to resist penetration of a bullet of 150-grain M2 ball ammunition having a nominal muzzle velocity of 2,700 feet per second (824 mps) when fired from a 30-caliber rifle at a distance of 100 feet, measured perpendicular to the target." Light anti-armor rockets have effective ranges (on stationary targets) ranging from 200 meters to 500 meters, and may be used to attack fuel depots or aviation as part of an overall camp attack strategy (U.S. Army 1+).

While armoring a target to withstand attack from a shoulder-launched rocket is difficult, embassies worldwide have used screens of fencing to cause such rockets to detonate prematurely. In theory, these rockets fundamentally function by utilizing a shaped warhead that upon detonation—when the armed warhead contacts the tank—creates a superhot jet-stream of gas that pierces the armor of the tank, raising the temperature inside the tank to approximately 5,000ºF and igniting the fuel and armament. A specific "standoff" distance is required for the convergence of the superheated gas from the conical surfaces of the shaped charge to form and focus the piercing jet. A barrier fence installed one meter or more away from a surface has been shown to cause premature detonation and incorrect focus of the rocket to reduce the potential for penetration and complete compromise of the barrier. Even multiple mats of heavy "hog/chicken wire" fencing have been used to this end.

Barrier walls or revetments behind screening should be sufficiently hardened to provide a barrier from the heat, concussion and shrapnel. In addition to light anti-armor rockets, indirect-fire weapons such as the 60 mm mortar can be effectively used even by highly mobile guerrilla platoons. "On April 9, 2001, the Angolan army found a major UNITA ammo dump, with 7,900 60 mm mortar shells . . . . Outside the town of Kalussinga, the Angolan Army found a cache with 1,000 rocket-propelled grenades" (Angola).

Once the perimeter clear zone is established, probable avenues of attack can be pre-sited and overlapping fields of fire established. Natural barriers within the camp should be considered for target hardening and rally points. Target hardening is relatively easy to accomplish by field expedient methods such as excavation, palisades, sandbagging and revetments.

Spatial orientation should complement security as well as fire control. Examine various scenarios and determine fall-back positions, layers of defense, armed cover of fire evac routes, multiple safe rally points at varying distances from the base camp and access to vehicles, boats and aircraft. Fire evacuation routes should be evaluated from a security perspective. Fire can be used to drive camp personnel into kill zone channels of concentrated weapons fire; in addition, delineated evacuation routes should be examined for potential exploitation as ambush zones. Natural features outside the camp perimeter that could be exploited by attacking forces should be evaluated for risk potential as well. These include rock outcroppings that could provide cover from small-arms fire or high points that could be used by snipers. Some prime firing positions may be reduced by prescribed burning or destruction by explosives or, alternatively, occupied as observation posts and counter-sniper tactical positions. Aggressors against a settlement can use intentional brush fires as a weapon, but by hardening the camp perimeter with a clear zone, such problems can be minimized.

High-Performance Operations

In an efficient field operation, security, firefighting and emergency medical response is blended to develop a well-rounded emergency response team (ERT). This methodology has proven advantageous in various settings where firefighters and armed police are cross-trained as emergency medical technicians. Ideally, an ERT should possess a comprehensive range of skills, including small unit tactics, advanced first aid and basic field skills, as well as firefighting knowledge.

Security personnel should be familiar with firefighting operations and the unique plans for the given camp. At industrial workcamps, the indigenous workforce may act as the primary firefighting force, with the security team supporting this group. At small camps focused on scientific research or surveying, security personnel may serve both roles. Armed police units typically reinforce firefighting teams in urban areas. Frontier bases must essentially provide their own quick-reaction forces including armed defense and counter-offense. Some host countries may provide some degree of limited rescue support, but typically the response time is so long that frontier camps must be prepared to operate as independent entities providing their own control of emergency operations. If a fire breaks out, armed security forces should secure the area. Regardless of whether the fire is accidental or intentional, the firefighting team and medics should be able to attend to their specialized task and not have to worry about self-defense.

Boats, aircraft and vehicles make good incendiary sabotage targets as well as bulk fuel depots. Areas that have the potential for sabotage should have restricted access. Like a cleared perimeter zone, restricted access areas are only secure as long as they are under surveillance. Observation posts, patrolling and counter-sniper teams can play a dynamic role in securing these hazards. The degree of militarization of a camp depends on the environment. Some operations may only need heightened "industrial" security primarily addressing theft and vandalism, while others may survive only by being fully militarized.

Conclusion

Efficient camp design is the product of the pragmatic organization of multiple competing demands. An optimized camp gains synergy by orchestrating all design parameters. Fire control and physical security are two main design imperatives for life safety. Strategic site design is the most cost-effective way to reduce risk. Routine practice of emergency response drills is the best way to limit loss. ■

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