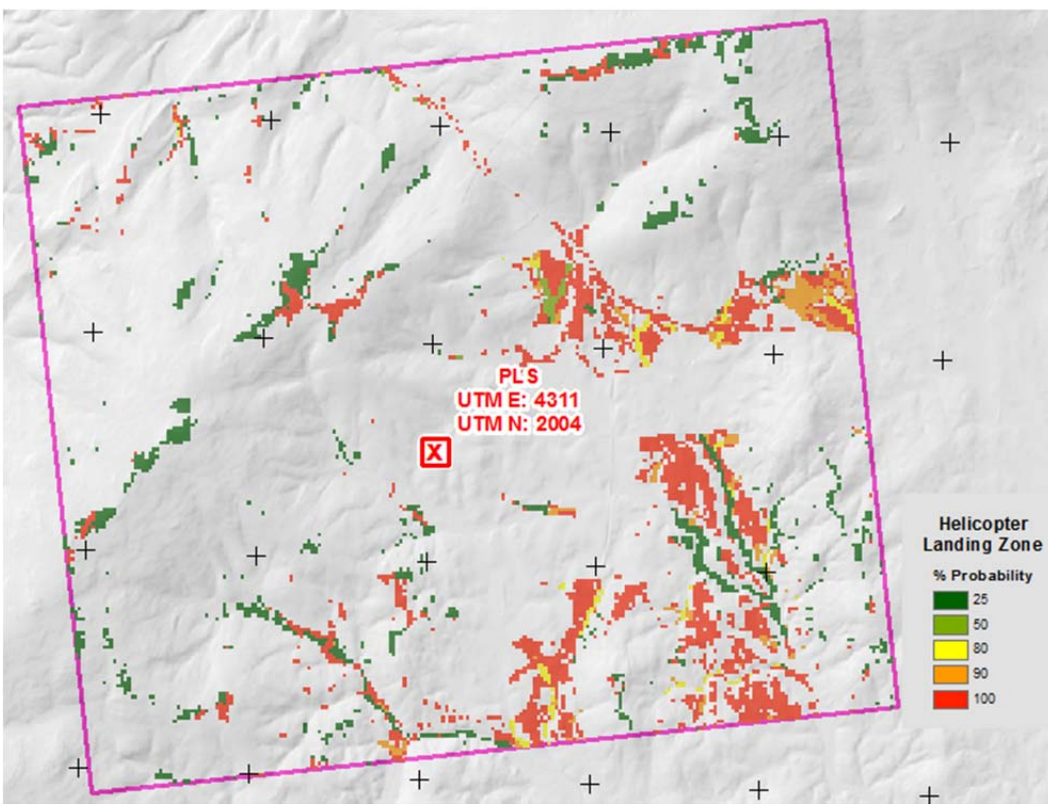
Estimating Helicopter Landing Zones (IGT4SAR_HeliLZ.py)

Disclaimer – in no way should this tool be considered over local expert opinion and that of the pilot. As outlined in iHOG (defined below), the pilot ALWAYS has the final say in accepting a designated landing zone.

Disclaimer – Currently there is no consideration given directly to Soil Composition.

Helicopters are an integral part of wilderness search and rescue as both an aerial search platform as well as providing logistical/operational support in ferrying searchers and equipment (and even the subject). Landing the helicopter is the preferred method of loading and unloading, however identifying an ad hoc landing location in a wilderness environment that meets the required specifications of a safe landing zone can be challenging. The intent of the Helicopter Landing Zone Estimation Tool within IGT4SAR is to provide an estimation of the suitability (Probability) of a location to be used as a helicopter landing area. The results of this tool, as shown is Figure 1, is a reaster layer with areas that have a greather than 0% probability of being suitable for helicopter landing based on a variety of readily available geospatial data layers that define slope, vegetation, prepared surfaces and aerial hazards. The tool follows an overaly approach similar to that defined in Ref [1 – 5].



The Interagency Helicopter Operations Guide (iHOG) provides specifications regarding the planning and construction of helicopter landing areas for helicopters of various Types. As described by Doherty et al

(2012), the iHOG describes environmental constraints in literal feature space with the objective of this tool being to translate this using geographical space. The recommendations provided in iHOG are based on the Type of helicopter being considered. iHOG defines three Types of helicopters:

Chart 6-1: ICS Type Specifications For Helicopters

TYPE	1	2	3
Useful Load @ 59° F. @ Sea Level	5000	2500	1200
Passenger Seats	15 or more	9-14	4-8
Retardant or Water Carrying Capability (Gallons)	700	300	100
Maximum Gross Takeoff/Landing Weight (Lbs)	12,501+	6,000-12,500	Up to 6000

iHog provides the following spcofocations for landing zones

Exhibit 8-1: Example of a Two-Way Helispot

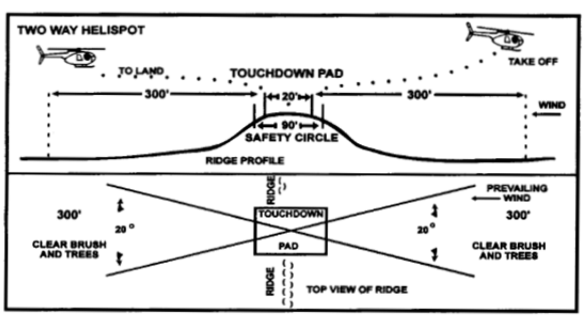
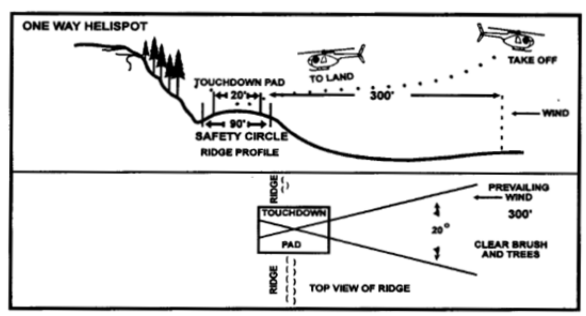


Exhibit 8-2: Example of a One-Way Helispot



- The Touchdown Pad is a designated area, that may have a prepared or improved surface, at a helispot or helibase that is used for takeoff, landing or parking of helicopters.
- The Safety Circle is a zone that provides an obstruction-free area on all sides of the touchdown pad. For helispots and helibases, the only items that should be within the safety circle are a fire extinguisher, a pad marker, and if applicable, external loads awaiting transport. The Parking Tender may also be within the safety circle.

Chart 8-1: Touchdown Pad and Safety Circle Dimensions

Type	1	2	3
Touchdown Pad Dimension	30' x 30'	20' x 20'	15' x 15'
Safety Circle Diameter	110'	90'	75'

Chart 8-4: Distance form Obstacles

Distance from edge of Safety Circle	Height of Obstacle
80'	10'
160'	20'
240'	30'
320'	40'

iHOG defines the minimal "Surface Features and Requirements" by considering slope, vegetation, soil composition/ground preparation (ie – "Pads must be firm enough to support the type of helicopter being used at temporary helibases and helispots."), Distance to Obstructions / Aerial Hazards, Approach/Departure Path. In translating this into a geospatial tool that runs within a GIS it is challenging to capture all of the detailed specifications for each type of aircraft. Additionally, the quality of the model is dependent on the quality of the geospatial data layers provided. As such, various assumptions and approximations had to be made especially considering this tool is required to be applied generally with minimal preparation to the various data layers within the GIS AND with minimal "Expert" input required by the user. Thus in many cases the worst case scenario is considered in instances where accurate data is not available or is not provided.

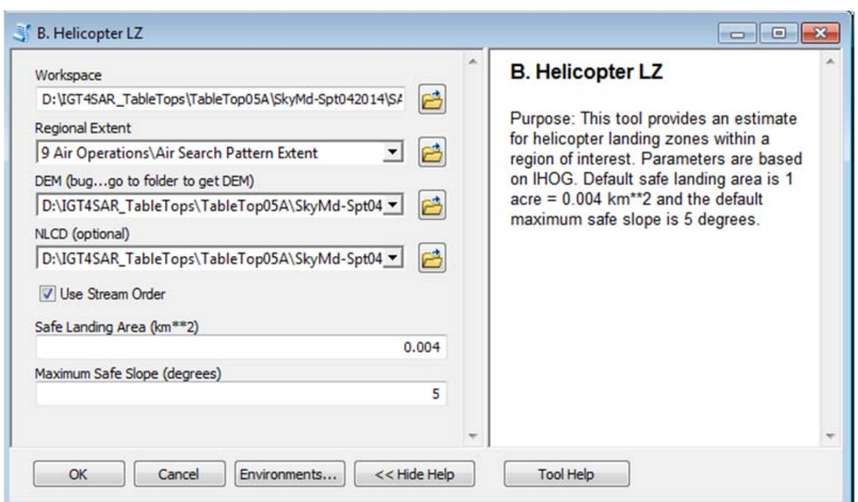


Figure 1: Helicopter Landing Zone Tool dialog box

The Helicopter Landing Zone Estimation tool provided in IGT4SAR performs a weighted overlay approximation based on input for Slope, Land Cover Classification (vegetation), prepared surfaces and aerial hazards. This tool was developed to function within the confines of IGT4SAR ArcGIS template and requires various data layers that are present within this template. Figure 2 below shows the tool dialog box presented to the user upon executing the tool. The only spatial data layer that is REQUIRED is the Digital Elevation Model (DEM). All of the fields present in the tool dialog box are discussed below with a description algorithms and specific data layers used by the tool following.

Workspace

The first required parameter is a definition of the Workspace. This permits raster and vectors layers to be saved to and extracted from the appropriate geodatabase. Within the framework of IGT4SAR, one of the easier methods for identifying the appropriate Workspace is to select the “Browser” icon to the right of the Workspace dialog box. When the “Workspace” dialog box opens select the “Home Folder” icon and finally select the SAR_Default.gdb.

Regional Extent

This is the area to be considered for analysis. This can be any polygon layer however, if the polygon feature is composed of multiple polygons it is recommended the user SELECT a single polygon. The user may elect to use one of the preferred data layers such as “8 Segment_Groups / Search Boundary” or “9 Air Operations / Air Search Pattern Extent”. Only areas within the designated boundaries will be considered.

DEM

The digital elevation model (DEM) is the only required data layer input for proper execution of the tool. The DEM is used to define the raster Cell Size and to determine the Slope throughout the Regional Extent. The DEM must be in the same Projected Coordinate System as the Regional Extent. The tool will produce a clipped copy of the DEM based on the boundaries of the Regional Extent.

NLCD (Optional)

The Land Cover Classification raster defines the types of land cover across the Regional Extent. The tool is currently only desired to work with land cover classification from the National Land Cover Classification dataset (http://www.mrlc.gov/index.php). Using the NLCD, the tool reclassifies Land Cover based on its potential as a helicopter landing site. Reclassification is based on the likelihood of a particular classification being composed of an aerial hazard or the likelihood of possessing a prepared surface. Some prejudice as some generalities are given to the reclassification of Land Cover that rely on either additional data layers for aerial hazards (defined below) or pilot verification. For example, the Land Cover Classification for “Developed, Open Space” is given a 100% Probability as being suitable for helicopter landing but Land Cover alone does not consider Slope nor the presence of aerial hazards. The tool is intended to be used in a “weighted overlay” fashion with Land Cover being one input overlay.

And of course the Pilot has the final say what constitutes an acceptable landing site. The re-classifications for Land Cover based on the National Land Cover Classification Dataset or given below:

LAND COVER CODE	DESCRIPTION	Probability	LAND COVER CODE	DESCRIPTION	Probability
11	Open Water	0	73	Lichens	90
12	Perennial Ice/Snow	85	74	Moss	90
21	Developed, Open Space	100	81	Pasture/Hay	100
22	Developed, Low Intensity	100	82	Cultivated Crops	90
23	Developed, Medium Intensity	100	90	Woody Wetlands	0
24	Developed, High Intensity	100	91	Palustrine Forested Wetland	0
31	Barren Land (Rock/Sand/Clay)	75	92	Palustrine Scrub/Shrub Wetland	0
32	Unconsolidated Shore	70	93	Estuarine Forested Wetland	0
41	Deciduous Forest	25	94	Estuarine Scrub/Shrub Wetland	0
42	Evergreen Forest	25	95	Emergent Herbaceous Wetlands	0
43	Mixed Forest	25	96	Palustrine Emergent Wetland (Persistent)	0
51	Dwarf Scrub	90	97	Estuarine Emergent Wetland	0
52	Shrub/Scrub	90	98	Palustrine Aquatic Bed	0
71	Grassland/Herbaceous	90	99	Estuarine Aquatic Bed	0
72	Sedge/Herbaceous	90			

As can be seen in the table, Water related features are given a 0% Probability with many forested classifications given a near zero (25%) likelihood of having a space with vegetation below 45 cm (18 inches) as specified in iHOG. The user, with a cursory knowledge of Python scripting, could modify these classifications (IGT4SAR_HeliLZ.py line 292).

Stream Order (optional)

The optional stream order gives some consideration to the size of the stream in defining stream/rivers as aerial hazards. Without the use of "Stream Order" all Streams/Rivers (as defined in the Streams data layer) would be considered an aerial hazard and be given a buffer of 100 meters (328 feet). This would include perennial or seasonal streams that only occasionally flow. By considering Stream Order a re-classification of streams as an aerial hazard (similar to land cover) is defined.

Safe Landing Area (km**2)

The iHOG specifies Safety Circle for a Type II helicopter as 90 feet (circle with area of 6362 ft**2 = 0.000591 km**2). This would be considered the minimal safe landing area as defined by iHOG. This does not consider the approach / departure path. In order to accommodate the needs for different

Types of helicopter and to allow the user an opportunity to consider the Approach/Departure Path, the Safe Landing Zone area is provided as a user input parameter. The value specified here is used in combination with the DEM raster cell size to determine regions of the specified Area within the defined Regional Extent that have a collective slope below the cutoff value (ie 5 degrees). This is performed using the RegionGroup tool within ArcMap.

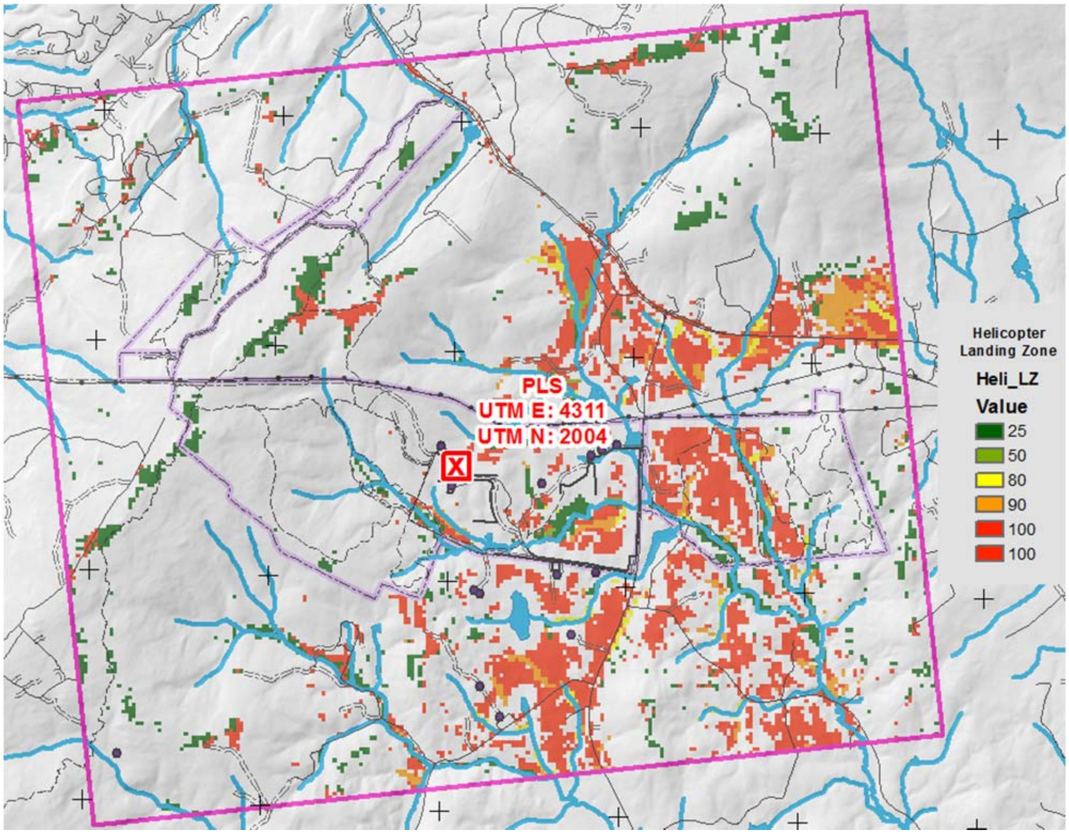
Maximum Safe Slope (degrees)

User specified value for the maximum safe slope. iHOG specifies 5 or 6 degrees is some situations. However, in specifying this value the user should give some consideration to the uncertainty within the DEM and subsequent Slope determination. Doherty et al (2012) detail a method for varying the weights of the slope near the specified safe slope value to account for data uncertainty. This was not done for the IGT4SAR_HeliLZ.py at this time at only slopes less than the Maximum Safe Slope as defined by the user are considered. This will be updated as time permits.

Below is a general outline of the workflow process followed and the additional data layers considered in the execution of the IGT4SAR_HeliLZ.py tool. For a detailed understanding of the operational of the tool the reader is referred to the script. One of the difficulties in creating a script for general applications is being able to consider all situations. The script has been created conservatively to account for its generality.

1. Clip DEM and other data layers (optional) to the extent specified in the Regional Extent and ensure appropriate projection and length units for each layer.
2. Use DEM to determine slope and identify regions with slope less than the maximum safe slope (user defined) that is equal to or greater than the Safe Landing Area (user defined).
3. Create a null raster at the extent of the Regional Extent layer that is used if optional data layers are absent.
4. Clip Land Cover dataset and reclassify for landing zone suitability.
5. Interrogate the “ASSETS” data layer to look for existing “Landing Zones” and general “Aerial Hazards”. These features are buffered according and converted to raster with the existing landing zones being given 100% suitability and aerial hazards given a 0% suitability. Additional Aerial Hazards are considered below. All existing Landing Zones and Aerial Hazards (regardless of height) are assigned a buffer of 100 meters.
6. Roads (ROADS data layer) features are buffered to a width of 2*cellsize and considered as 100% suitable for landing areas although they must meet the additional overlay specifications (slope, land cover, etc).
7. Streams (STREAMS data layer or Stream Order using DEM) features are considered 0% suitable unless the user elects to perform Stream Order calculation. At 0% suitability streams are buffered to 100 meters.
8. All water bodies (Water_Polygon or Waterbodies) are considered 0% suitability as per iHOG. Buffered to 100 meters.

9. All fencelines (FenceLine data layer) either real or virtual are considered 0% suitable. Creation of virtual fencelines permits the user some flexibility to eliminating some areas of the Regional Extent if so desired. Fencelines are buffered to 100 meters.
10. The PowerLines data layer contains a field to specify if the utility is above ground (powerlines) or below ground (some pipelines). If the utility is identified as below ground it is buffered to 2 * cellsize and defined as 75% suitable (still dependent on other overlays – slope). If it is defined as Above Ground it is given 0% suitability and buffered to 100 meters. If no distinction is given as to above or below ground, the feature is considered to be above ground and given 0% suitability buffered to 100 meters.
11. Buildings (Buildings data layer) are considered aerial hazards are buffered to 100 meters and assigned 0% suitability regardless of height. It should be noted that the land cover classification for developed areas is re-classified as 100% suitable if no Building Point Features are defined.
12. CellTowers (Celltowers data layer) are considered an aerial hazard buffered to 100 meters and assign a 0% suitability.
13. Overlays are weighted according to their importance in defining a potential landing zone (in order of consideration)
    a. Existing Landing Zones
    b. Slope less than maximum safe slope value
    c. Aerial Hazards
        i. Aerial Hazards (aerial hazard, Fencelines, Utility – above ground, Celltowers, Buildings)
    d. Surface Preparation
        i. Roads, Waterbodies, streams, land cover
14. A Raster is prepared defining the suitability of the area to helicopter landing zone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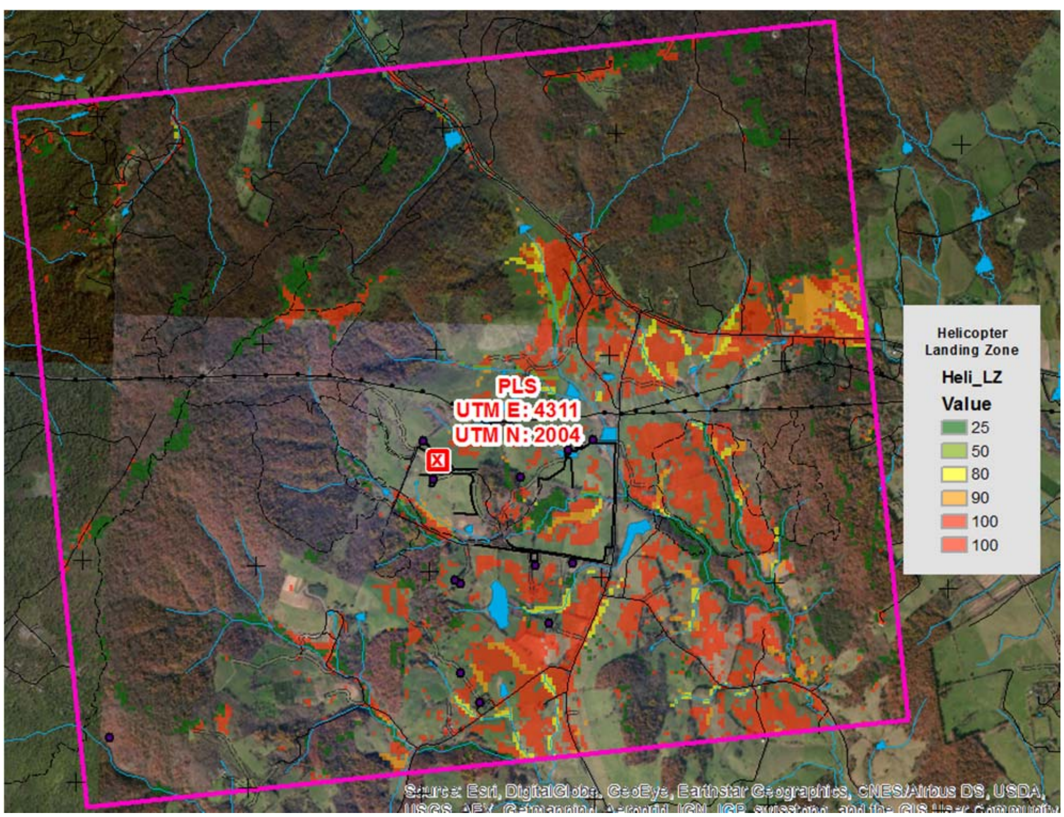
UTM E: 4311
UTM N: 2004
Helicopter Landing Zone
Heli_LZ
Value
25
50
80
90
100
100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100
100
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA,

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1. “GIS Tool for Siting Helicopter Landings.” 2015. GIS Tool for Siting Helicopter Landings. Accessed January 15. http://www.fs.fed.us/t-d/programs/forest_mgmt/projects/gisheli/.
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6. “Interagency Helicopter Operations Guide”, (Feburary 2013), National Wildfire Coordinating Group, PMS 510, NFES 001885.