Title: ***Aircraft (C-130J and CL-415) Analysis using LANDFIRE data in the Western United States***
Date: 2011-2012

Background: Over the years, many studies have been done to evaluate aerial firefighting resources relative to federal aviation strategies. While these studies considered things such as the number of airtanker bases, aircraft speed, and carrying capacity, they have not evaluated variables such as protection area extent, fuel and topography characteristics, and/or initial attack success rates, with a mix of aviation resources. A recent analysis compared the capability and carrying capacity of two powered fixed winged aircraft, the C-130J and CL-415, with fire history, fire behavior, and topography information to evaluate effectiveness in fire suppression activities in the western United States. The analysis did not evaluate fire retardant vs. water effectiveness. The analysis considered time and distance to fires, availability of suitable scoop sites, reload intervals, fire behavior fuel models (FBFMs), and vegetation canopy characteristics using LANDFIRE geospatial data. LANDFIRE was chosen because it encompasses the entire U.S., regardless of jurisdiction.

Methods: For the aircraft comparison, the analysis determined areas of operation with suitable scoop sites that had acceptable reload intervals, factoring in fire history and fire behavior information for the CL-415 amphibious aircraft, as compared to the C-130J land-based aircraft. The fire history was used to determine areas with historically higher numbers of fire starts, based on the USDA Forest Service Fire Occurrence Database (FOD) and used LANDFIRE FBFM and other inputs to model fire behavior attributes of flame length and rate of spread to determine whether direct attack was appropriate. The analysis used 29 existing C-130J Airtanker Bases (ATB) as a center points to develop Flight Circles[1] (FC) [Figure. 1] for a comparison between the aircraft even though their uses in how they are applied may be different. Next, an analysis of suitable scoop sites and percentage of FC that could be covered by water scooping CL-415 aircraft were determined. This was done by evaluating the minimum ingress/egress and water depth requirements for scoop sites (lakes, reservoirs, etc.) by using the digital terrain model[2] and extending it in to the bodies of water to determine areas of suitable scooping depths. Then, the percentage of each FC that could be covered, or serviced, was summarized by plotting the area within a 15-minute reload interval (consisting of a load, drop, and return) from each scoop site, known as the Serviceable Area (SA). An example is shown in Figure 2.

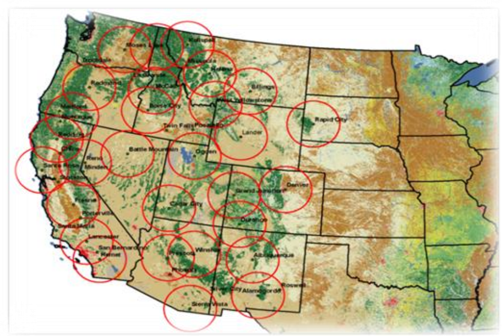

Figure 1 – Western United States study area. Red Flight Circles denote analysis areas.

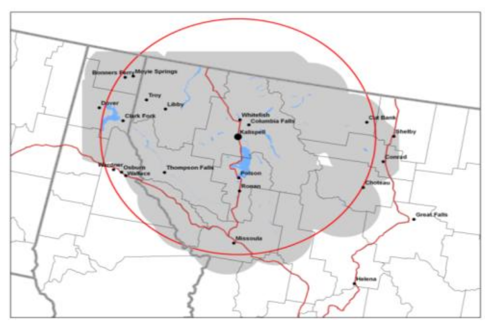

Figure 2 – Kalispell, MT. FC and SA with areas in gray represent 97% of FC can be serviced by the CL-415 aircraft.

With aircraft requirements in place, the analysis evaluated direct firefighting attack success by considering the effect of vegetation canopy presence or absence on an aircraft drop's ability to influence the surface fire behavior for three discrete classes (low, moderate, high - where higher canopy intercept would result in less retardant on the fire). Canopy intercept classes were developed using LANDFIRE 2007 Rapid Refresh[2] data, including canopy height, canopy cover, canopy base height, and canopy bulk density. Each FC was analyzed to determine which wildland fire starts (data from the FOD), may require aircraft support and which flight circles may have similar aircraft support needs based on predicted fire flame lengths and rates of spread using LANDFIRE fuel models in the FlamMap model.

Each FC was then sorted according to flame length into Air Support Classes (ASC). ASC 1 was considered more suitable for ground resources as these fires were "less likely" to require air support. ASC 2 and 3 were considered to have starts with potential need for air support and were "likely" and "most likely," respectively, to require air support to assist ground resources. The sorting of FC into ASC revealed similar fuel models in air support classes 2 and 3 and identified trends in FBFMs between FC. With this information, a final grouping of all FC into three "Flight Groups" was accomplished, thus indicating areas where deployment of the CL-415 was possible given landscape conditions (see the report[4] for these deployment areas).

The aircraft were dispatched from the same locations (FC centers – where C-130J aircraft are deployed) in the western United States and at the same time. The C-130J was displayed [Figure 3] with two airspeeds--250 mph and 350 mph below and above 10,000 ft elevation, respectively. The CL-415 was displayed with an airspeed of 200 mph below 10,000 ft elevation. The distinction between above and below 10,000 ft elevation was based on the Federal Aviation Administration requirement that all aircraft travel at a maximum airspeed of 250 mph below 10,000 feet (rationale being that, in order to go faster, an aircraft must climb above 10,000 ft elevation). In wildland firefighting operations, it is uncommon for retardant or water carrying aircraft to climb above 10,000 ft elevation to complete most missions. The report[4] made this distinction based on the current Federal aviation strategy[3] (NAIC 2007 / 2009).

Results: The report[4] provided the following information as presented in figure 3. The X-axis represents 15-minute reload intervals (RIs). Thus, example RI 4 in the figure represents one hour since dispatch (15 x 4 = 60 minutes). At RI 4, one C-130J (in red on the graph) is traveling at a speed of 350 mph. This aircraft arrives, makes its first drop at RI 5 – 3,500 gallons. The aircraft is then on the "load and return" leg back to the Airtanker Base (ATB). At RI 6, the other C-130J is traveling at a speed of 250 mph.

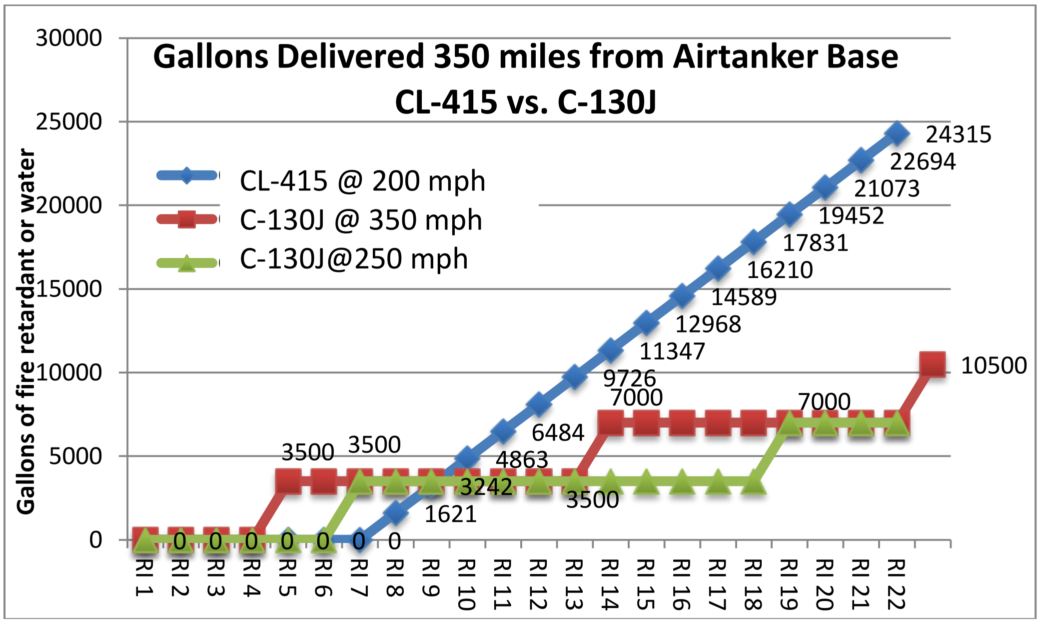

Figure 3 – Comparison of CL-415 and C-130J for gallons delivered for 15-minute reload intervals (RI).

The aircraft arrives, makes its first drop at RI 7 – 3,500 gallons; and like the first, returns to load at the ATB. The CL-415, flying at 200 mph arrives at RI 7, makes its first drop at RI 8, and due to its specifications is able to load and return at each subsequent 15 minute RI. At RI 10, the CL-415 has dropped 4,863 gallons and made up for its slower airspeed and smaller capacity. At this distance, it has 2.75 hours of fuel remaining and can likely stay on target for at least two more hours (or 8 more loads – until RI 15) before leaving the target. A key consideration of the CL-415 is that it does not have to return to the point of origin to refuel because it can take advantage of any airport that is closer with a 3,000 ft runway and Jet-A fuel. The increase in time on target and short reload intervals increases the volume (fire retardant or water) that is applied to the fire, therefore, reducing the fire rate of spread and reducing the potential of the fire to become established. LANDFIRE data provided FBFM data that was processed in FlamMap to generate flame length and rate of spread attributes, both of which are wildland fire characteristics used for assessing fire spread. These attributes were used to evaluate the typical aircraft suppression response given these characteristics. The analysis considered vegetation or fuel type canopies and air support classes which determined whether direct attack was appropriate. Regarding "how fast," "how much," and "how long," the C-130Js at 250 and 350 mph have reload intervals of 3.5 and 2.5 hours, respectively. Each will have traveled over 1,050 miles to drop only two loads of long-term retardant. The C-130J is tethered to a fixed number of airtanker bases and has limited time on target and long reload intervals, potentially allowing fire growth (not accounting for fire retardant effectiveness) and offsets any positive effects of the first drop. Fires with a rate of spread of 125 chains per hour will travel over 3 to 4 miles from the point of origin before the second drop from the C-130J arrives. As demonstrated in this scenario, larger capacity and faster air speeds are not necessarily advantages.

As reported in the analysis, the CL-415 specifications make up for slower air speed, smaller capacity, and use of short-term retardant (water). The CL-415 could be prepositioned at alternative airports, creating the tactical advantage of mutually supportive FC with shorter time and distance to wildland fires. The report does not conclude that "one size - fits all occasions;" however, the future mix of firefighting aircraft across appropriate landscapes should include both land-based and amphibious aircraft to be effective and efficient.

Management Implications:

The use of geospatial data such as LANDFIRE allows for analysis and assessments to be performed that were not previously possible. Analyses like this, allow for a more in-depth look at the variables that are important to wildland firefighting, while providing a holistic view of the natural resources and wildland fire environment to management and decision makers.

For the C-130J/CL-415 comparison, a review of the fire history and types of wildfires encountered in management areas provided new information on predominant fuel types and their associated fire behavior characteristics considering the aircraft specifications relative to fire suppression effects. In the case of the CL-415, only certain locations proved to be suitable deployment areas (for these locations see the detailed report[4]).

The comparison of the C-130J and the CL-415 illustrates the latter's ability to deliver a greater quantity (water) due to shorter load and return legs and its capability to remain over target longer despite its slower airspeed and smaller capacity. One possible scenario is dispatching CL-415s in flights of two or more where the CL-415 is likely to suppress fires in any of the predominant fire behavior fuel models.

Recommendations:

This analysis used LANDFIRE 2007 Rapid Refresh data[2], which is not the most current LANDFIRE dataset available and it would be good to see if the results are affected by updated LANDFIRE data.

This analysis only evaluated the western United States. It would be beneficial to perform a similar analysis comparing the approach to results for the entire United States as limited portions of the country use a mix of aircraft platforms like this for wildland firefighting.

Notes & References:

[1]*Flight circles delineations and serviceable areas provided by Dr. Robert Klaver, DOI USGS Center for Earth Resources Observation and Science.*

[2]*LANDFIRE 2007 Rapid Refresh data (accessed www.landfire.gov in 2010)*

[3]*National Interagency Aviation Council, 2007. Interagency Aviation Strategy. Bureau of Land Management, Bureau of Indian Affairs, National Park Service, U.S. Fish and Wildlife Service, National Association of State Foresters, D.O.I. Aviation Management, U.S. Forest Service. Final Report, December 7, 2007. Approved 2008 and modified 2009*

[4]*For more information and the detailed report; see Crittenden, Daniel A., Hann, Wendel J. Hann, 2011. Operational Evaluation of the CL-215T/415 for Initial Attack in the Western United States. Report from FIO Group LLC. (danielcrittenden@comcast.net)*