TopTask
Meteorological Flight Planning for Soaring

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Summary

Modern meteorological forecasts for gliding provide the diurnal evolution of convective lift rates and of the wind. Both are crucial for scheduling soaring flight tasks. A software tool named *TopTask* has been developed to establish flight plans for individual flight tasks. Flight plans can be obtained for all types of soaring flight: slow gliders with low glide ratios and wing loadings, which are more sensitive to wind, as well as fast gliders with high glide ratios and wing loadings. An interactive pre-flight optimization of tasks is possible in real-time for all types of gliders and based on routine forecasts. Tactical decisions, such as clock- or counter-clockwise attempts to fly a triangular task, can be supported. Analysis of recorded flight data and their comparison with the forecasted meteorological flight plan can be useful to meteorologists and pilots. The task setting for individual and for contest flights is hoped to be substantially simplified with this new tool.

Introduction

Meteorological flight planning for soaring can be based on forecasts for regions with homogeneous flight conditions. Such a concept is in operational use at several European weather services based on the regional convection model REGTHERM[1] nested to global and/or mesoscale numerical models for the synoptic evolution. Averaged lift rates in thermals are obtained from such regionalized forecasts. They can be used to assess the cross-country speed of a glider[2-4] and, thus, its potential flight distance PFD (?) The numerical models for the synoptic evolution can also provide the wind field in the convection layer.[5] With wind and cross-country speed forecasts available along a flight task, the planning of flights becomes possible. A program named TopTask has been developed for routine flight planning.

Polygons all over

Forecast regions are defined by polygons. The regions are selected on a climatological and a geographical base to show homogeneous cloud base altitudes on convection days. Region sizes range from about 1,500 km^2 in complex terrain to 10,000 km^2 in flat country. The corresponding length scale is 40 km to 100 km. Germany and the Alps, e.g., are covered by 123 regions. With an average size of 5,000 km^2, the horizontal scale is about 70 km. On good soaring days, glider flights with modern sailplanes will cover several forecast regions.

Flight tasks are also polygons defined by turnpoints. A flight task may be broken down by successive waypoints with a limited spacing. At a cross-country speed of 100 km/h, a spatial resolution of 10 km corresponds to a temporal resolution of six minutes. For each waypoint, the corresponding forecast region must be figured out. Establishing a task schedule consists of finding the altitude and time for each waypoint along the task.

Flight Strategy

Let a flight start at a specified height (e.g. 1000 m above ground) and time. The forecast lift rate for the corresponding location (region) and time of day can be converted to the corresponding *cross-country speed*, Fig. 1 (Figures begin on pg. 3), according to the type of glider used.[4] The heading of the glider is chosen in such a way as to yield the track defined by the current leg when combined with the corresponding forecast of the synoptic wind, Fig. 2. (Pg. 6) With the track components of the horizontal wind and of the cross-country speed progress is made along the current leg without losing altitude.

Cross-country speed may be too low to cope with strong head wind or lift rate may be less than a threshold value (e.g. 0.3 m/s). In these cases flying at constant altitude with no or unsatisfactory cross-country speed is either impossible or very slow. Altitude can be traded in for *gliding speed* (faster than cross-country speed) in order to reach the next waypoint. Again, the track component of the gliding speed must be figured out considering the horizontal wind and also the track component of the glide ratio. Eventually the next waypoint is reached at the expense of some flight altitude.

At each waypoint, the current flight altitude should remain above ground. Additionally, it may also be possible to climb to higher altitudes if the lift rate permits so. This may occur when changing to a different forecast region, or when the convection depth changes during the day. Cross-country flights into elevated terrain are slowed down by this. On the other hand, it may not be possible to maintain altitude when entering lower lying regions. Excess of altitude can be used to fly at the faster gliding speed down to the lower convection altitude. This increases the overall speed for the task. A further point to check periodically is the possibility of a final glide.

Flight planning with TopTask

The criteria described above were programmed into an algorithm named TopTask for scheduling flight tasks based on the regionalized forecasts of lift rates as available from REGTHERM.[1] Convective lift rates are converted to cross-country speed by the classical speed-to-fly theory. Glider performance is considered through a polar deduced from the best glide ratio and the corresponding gliding speed. The polar is adjustable to other wing loadings and is automatically adapted to air density as a function of flight altitude. Cross-country speed is then combined with the horizontal wind to give the ground speed along a leg of a task. Temporal and spatial resolution of the forecast atmospheric motion - particularly the lift rates - is now sufficient for the calculation of flight schedules. Flight plans with *TopTask* include final glide calculations. Task speed is optimized by varying the time of departure.

The task shown in Fig. 3 is a 725 km triangle in the Western Alps to be flown on a day in June. Start and goal are on the leg to the southeast. The glider is an Open-Class sailplane with a handicap of 124. Departure time is 11:45 hrs local. The flight path to the first turnpoint has a slight crosswind component. On the second leg, the initial tailwind at intermediate altitude changes into a crosswind when reaching an elevated region with a higher convection altitude. Crosswind can be expected all along the way to the turnpoint in the northeast. The final glide begins on the third leg at about 4200 m MSL, 130 km before the end of the task and meets various headwind components depending on the region and flight altitude. The last turnpoint to the NW is reached during final glide. The average speed for this task is expected at 104 km/h, and the arrival time is 18:26 hrs.

The benefits of TopTask for task setting are shown in Figs. 4 and 5. For example, a contest director considers a task around Mont Blanc with a distance of 603 km for Standard-Class gliders. Figs. 4a and 4b show that in the given weather conditions this flight is impossible in the anticlockwise direction. Figures 5a and 5b, however, show that the task can be flown in the clockwise direction - even with a Standard- Class glider. This difference is caused by the strong westerly wind in the north part of the planned route (Figs. 4a and 5a), and by the difference of the development of thermals and clouds at every one of the cruised TOPTHERM areas (Figs. 4b and 5b).

With today's user interface techniques task setting becomes a matter of a few mouse clicks, as is the individual optimization of a scheduled task. Reversing a closed task with more than two legs may affect the overall speed and TopTask can tell you how much.

The German Weather Service DWD offers meteorological flight planning with TopTask to the soaring community for central Europe.[6] TopTask and TOPTHERM are available to pilots as components of the self-briefing system *pc_met*.

Conclusions

Combining regionalized forecasts for lift rates and synoptic winds with glider performance allows the calculation of soaring flight tasks over complex terrain. The task setting can be optimized with respect to the selected take off location and the type of glider. The planning of flights can be extended to other types of soarers like microlift gliders, hanggliders, paragliders, or even migrating soaring birds. Flight planning with other types of lift (slope, cloud street, and wave) will become straightforward once meteorological models exist that forecast lift rates in these phenomena.

The comparison of GPS-based flight documentation with corresponding TopTask flight planning may assist weather services in improving the reliability of their forecasts of wind and lift. Thus, pilots may simply enjoy planning and flying their tasks.

References

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[3] Irving, F., *The Paths of Soaring Flight*, Imperial College Press, 1998.

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[6] Leykauf, H., "TopTask - Streckensegelflug exakt geplant, " *Aerokurier*, Dec. 2002, pp. 84-88.

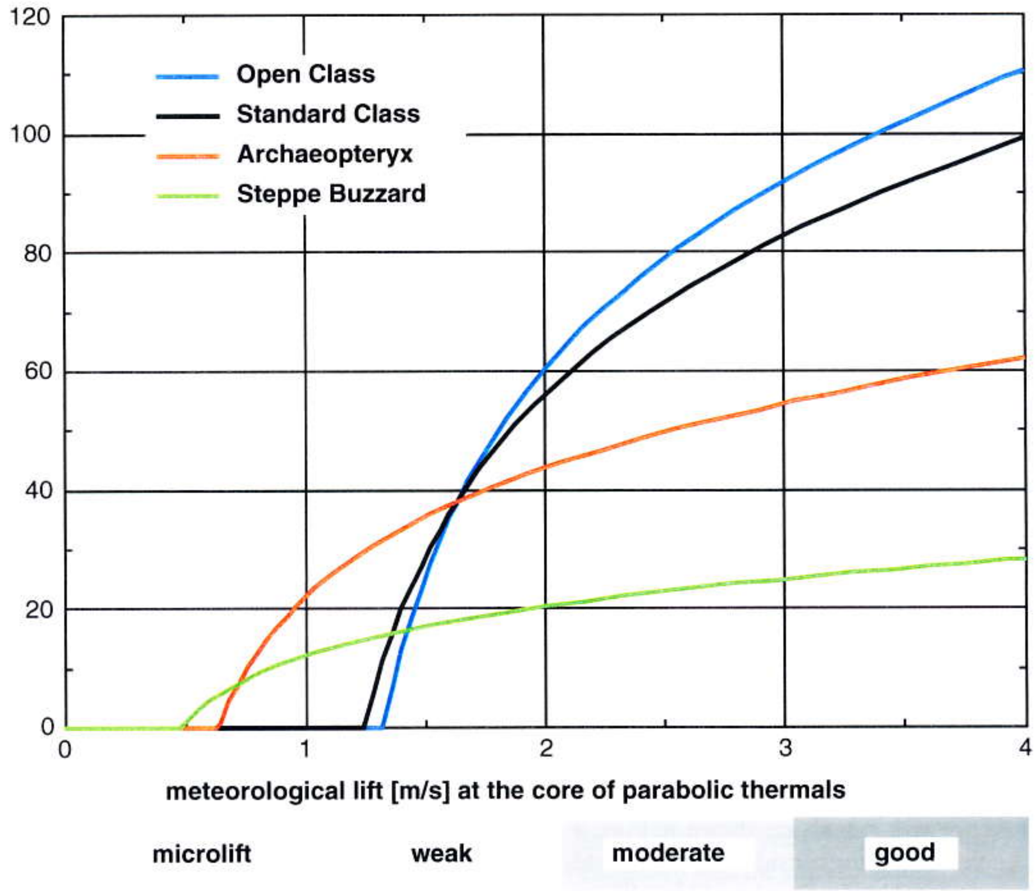

Figure 1 Cross-country speed [km/h] for different types of gliders and a migrating raptor.

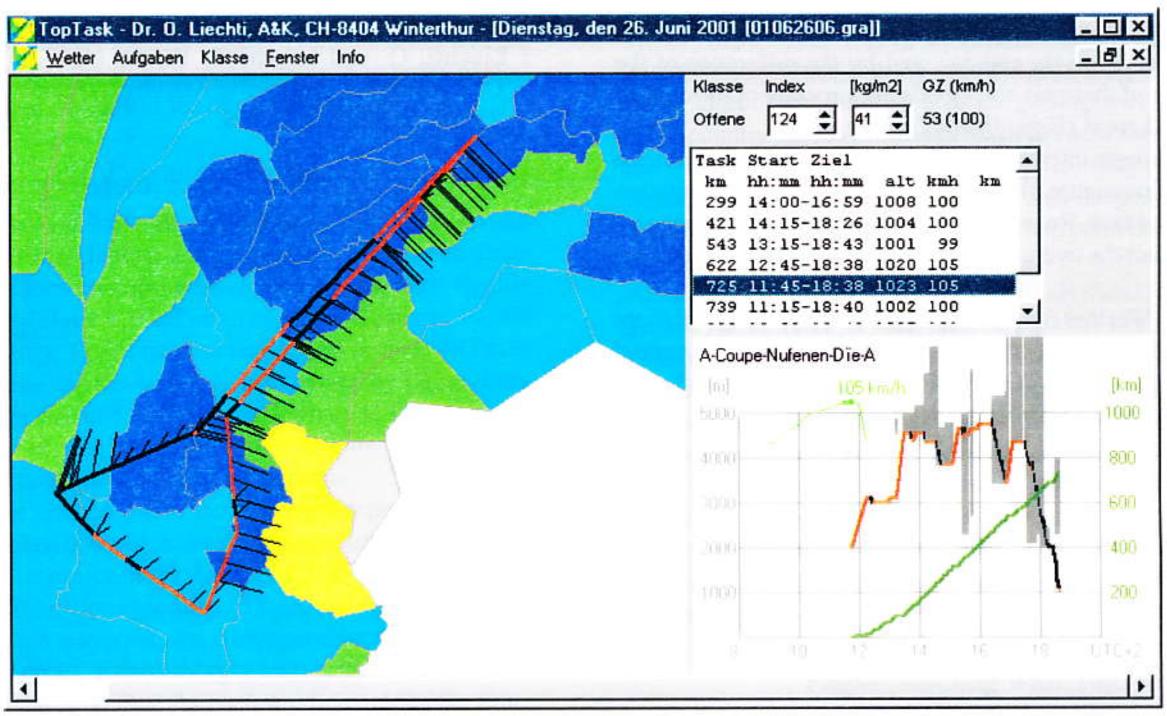

Figure 3 Scheduled flight task in the Western Alps.

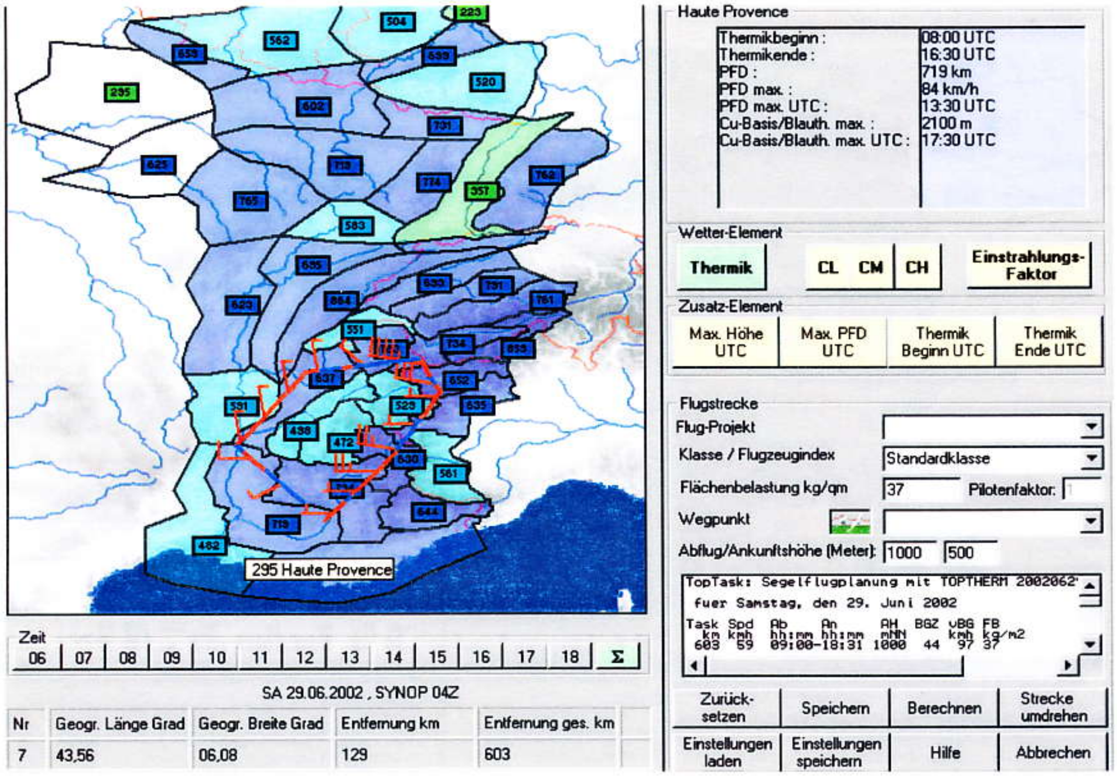

Figure 4a Flight around Mont Blanc in anticlockwise direction.

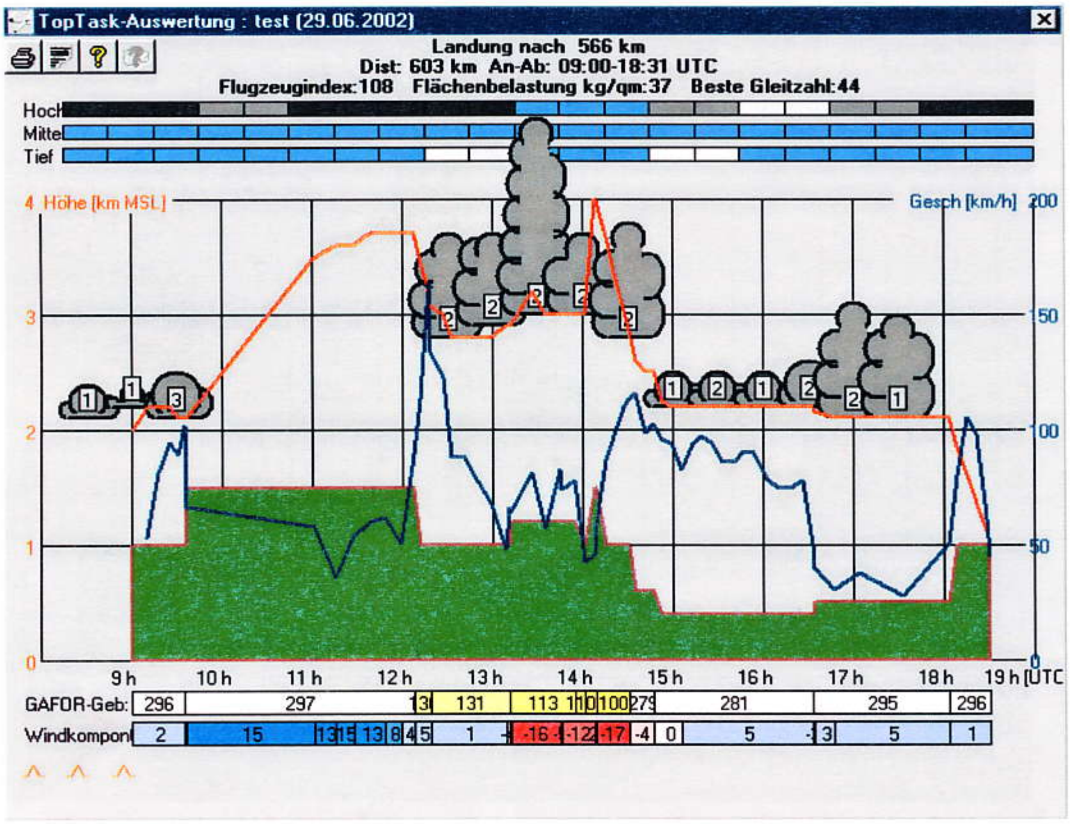

Figure 4b Flight around Mont Blanc in anticlockwise direction.

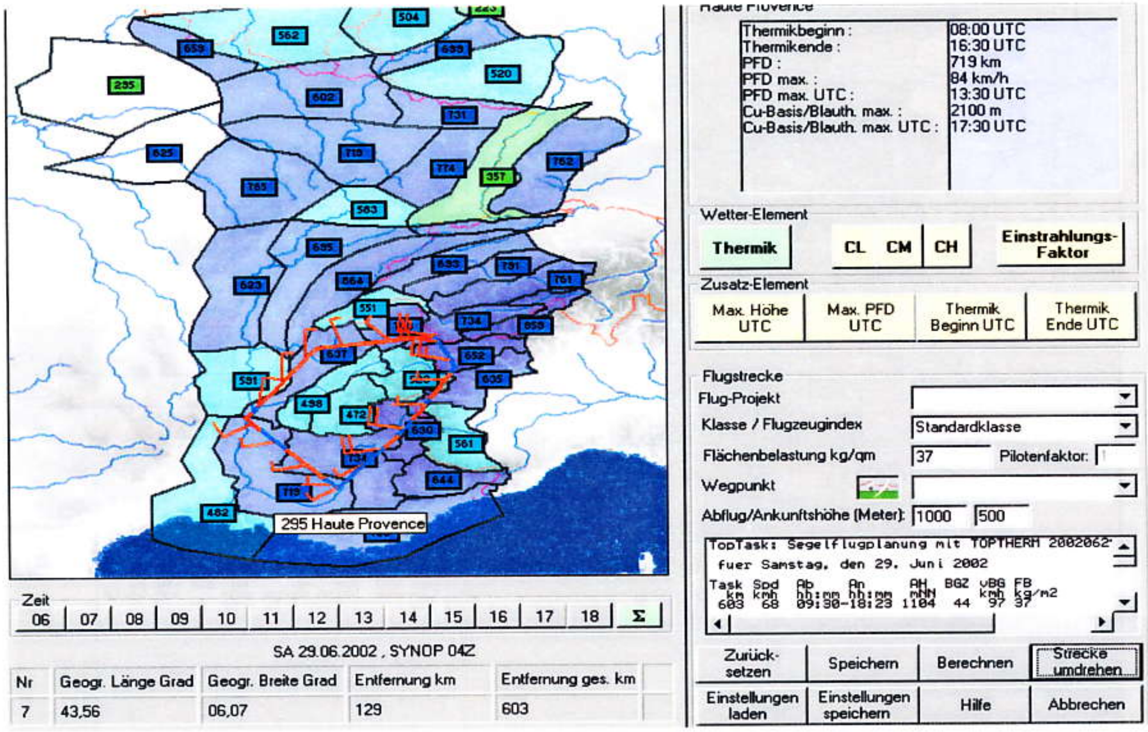

Figure 5a Flight around Mont Blanc in clockwise direction.

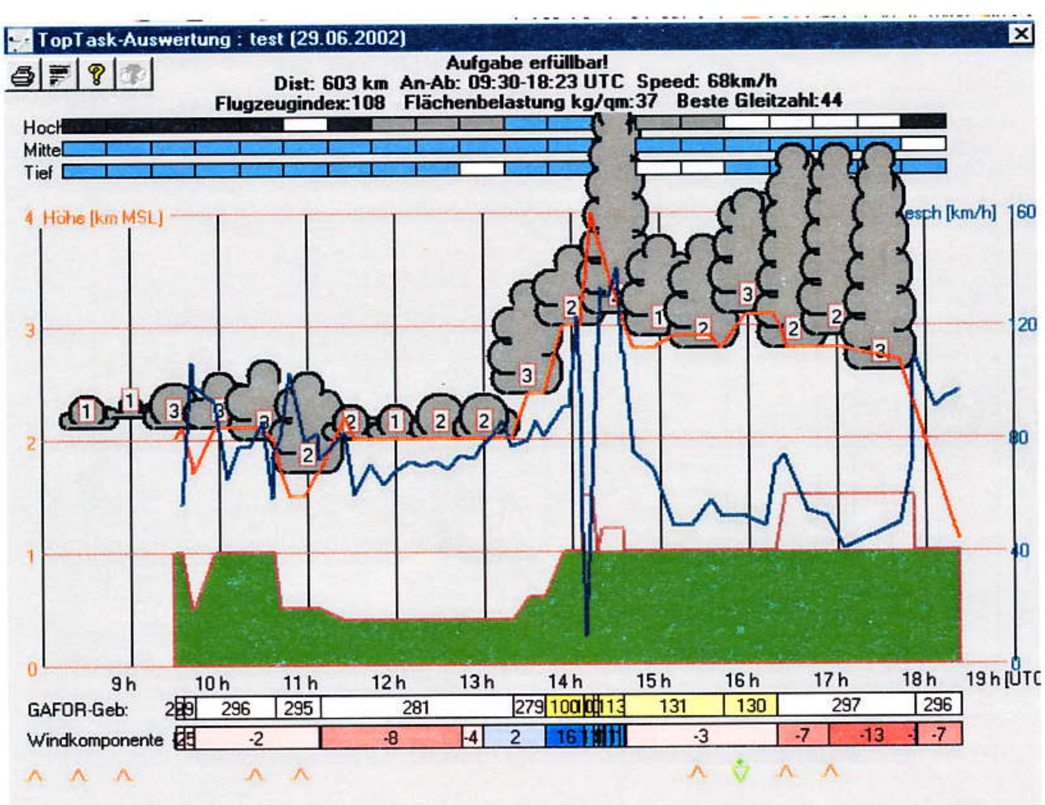

Figure 5b Flight around Mont Blanc in clockwise direction.

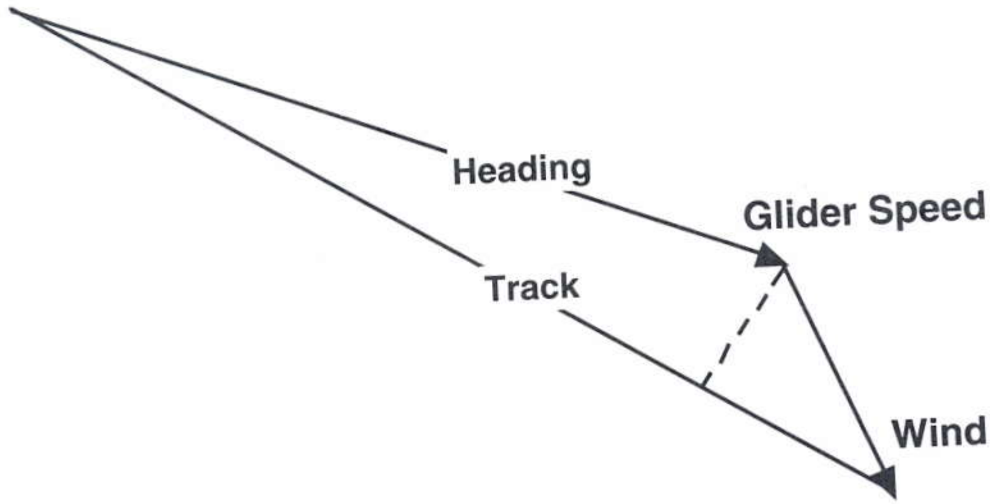

Figure 2 Combining wind with glider speed and heading for a desired track.