

### Pitch Control Mode

Under normal operation, Intellislope uses both the location provided by a GPS receiver and the signal from a pitch sensor mounted to the plow's shank in order to effect control of the elevation at which tile is installed. However, it is possible to operate Intellislope without the benefit of a GPS receiver, using the pitch sensor to control only the pitch of the shank.

In normal usage the recommended modes of operation are "Grade Control" and "AutoTile", the first two options on the main menu shown in Figure 1. These two modes both use GPS location and elevation to perform depth control on the plow.

Pitch Control mode is accessed via "Non-GPS Pitch Control", the third option on the main menu. When operating in Pitch Control mode, Intellislope does not control the elevation of tile installation. It merely holds the orientation of the shank at the specified pitch. The desired pitch of the shank is adjusted using the "Shank Pitch Setpoint" value at the top left corner of the Pitch Control screen shown in Figure 2.

A basic principle of pitch plows is that they tend to travel through the ground in the direction in which they are pointed (meaning, parallel to the skid plate on the bottom of the shank). Thus one would expect that when in Pitch Control mode, the plow will install tile with a grade matching the selected pitch. However, due to various factors including soil conditions, error in the pitch sensor calibration, obstructions such as rocks, geometry of the plow and so on, the correspondence will not be exact.

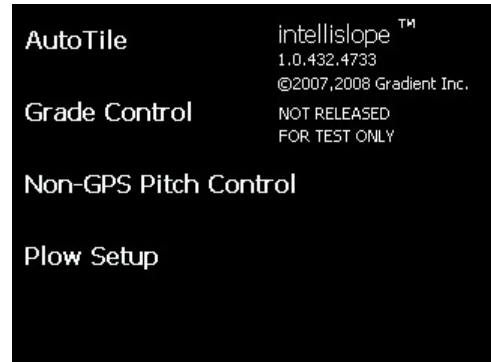


Figure 1: Main Menu

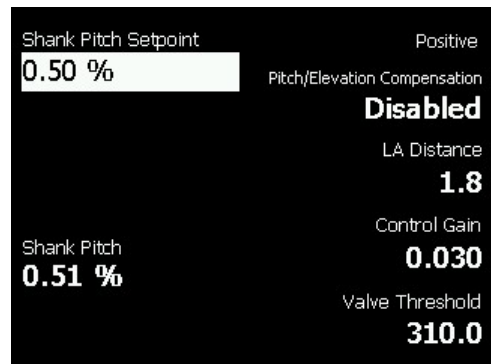


Figure 2: Pitch Control Mode Screen



Figure 3: Plow installation profiles when operated at various pitches

To help understand how closely one can expect the installed tile profile to correspond to the selected pitch setpoint in Pitch Control mode, we collected the data shown in Figure 3. To collect this data, we operated a Soil-Max Gold Digger plow fitted with Intellislope. The Leica Mojo RTK GPS receiver was disconnected from the Intellislope CDU (Cab Display Unit) and instead connected to a laptop for logging of the GPS. The plow was operated in Pitch Control mode at a fixed pitch setpoint, and GPS was logged on the laptop. Prior to the run the pitch zero was calibrated by operating the plow in Grade Control mode, and then adjusting the pitch zero on the plow setup screen to match the auto calibration value.

One observes that the plow tends to follow a profile matching the selected pitch. In each case a higher pitch results in a profile that rises more. The one exception is the profile created when operating at -0.25% pitch, which is slightly higher than the -0.50% pitch profile. The 0% pitch runs level for about 40 meters before dropping a few inches at the 45 meter mark.

The installed grade can be found by fitting a slope to the profile using linear regression. Plotting the installed grades versus their corresponding pitches yields the plot shown in Figure 4.

Based on these observations and the preceding discussion, a few guidelines recommend themselves:

1. Grade Control and AutoTile modes are preferred over Pitch Control mode, and should always be chosen when GPS is available.
2. Pitch Control mode results such as those presented here depend upon a recent pitch-zero calibration setting (which requires operating Intellislope with GPS).
3. In a circumstance where GPS is not available (such as satellite obstruction due to trees or buildings), Pitch Control mode may be utilized.
4. Pitch mode should be utilized with a grade of at least 0.5% with no expectation that installed grade will match any better than +/- 0.25%. Soil conditions may cause even larger deviations. Wet or "soupy" conditions in particular may allow the plow to sag or drop more so than would be the case with dry ground.
5. Ground that possesses a significant continuous positive grade (0.5% or more) is conducive to operation in Pitch Control mode. By observing the plow's chain, a constant depth may be maintained. When the plow is observed to run deeper than the desired depth, the Shank Pitch setpoint can be increased to cause the plow to run shallower. Conversely when the plow runs shallower than the desired depth, the Shank Pitch setpoint can be decreased to cause it to run deeper. Regulating the setpoint in this way maintains a constant depth. A constant depth in conjunction with the ground's natural grade will produce good drainage characteristics.

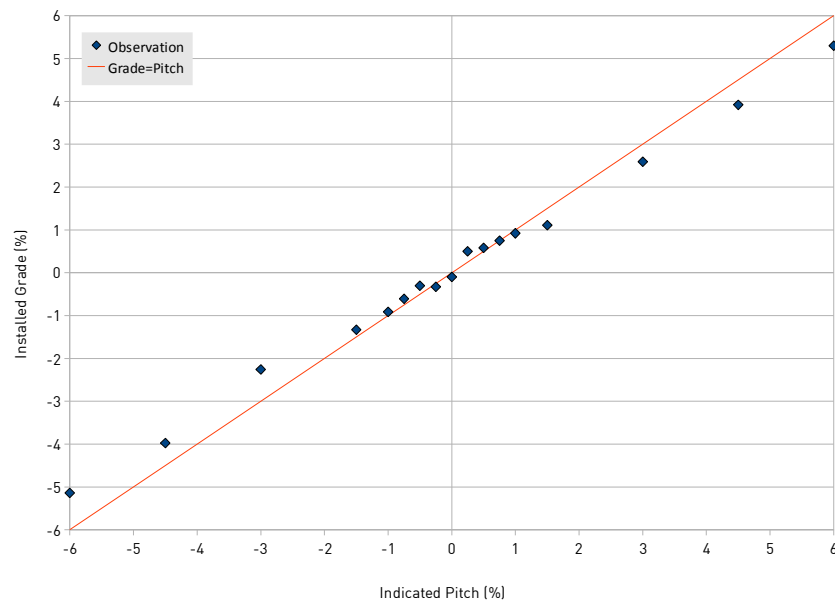


Figure 4: Installation grade versus shank pitch