

WHAT IS STRIPALIGN?

Geometric error correction for airborne LiDAR

StripAlign is an automatic strip alignment tool: it registers overlapping LiDAR swaths and corrects both relative and absolute geometric errors. It allows to effectively reduce discrepancies between strips due to IMU attitude and position errors, and to combine corrections optimally in order to minimize both relative and absolute error. It uses a rigorous time-dependent approach to address effects such as IMU drifts and oscillations, which cannot be corrected with classical sensor calibration.

The registration algorithm takes advantage of all the last returns, filters out outliers on the fly (including vegetation, mismatched building walls, missing and bad data). LAS ground classification can be used if available but is not necessary. A roughness threshold can also be used to exclude vegetation and speed up the computation. Water bodies can be filtered based on height. No planes, or geometric objects of any type are required: natural surfaces work just as well as built-up areas.

It is possible to set some of the strips as references to keep them fixed, when they are part of an already aligned dataset, which saves time. No control data is required, but if available they can be used for QC and vertical bias compensation.

Required inputs and formats - point clouds and trajectories

Industry-standard LAS, LAZ and ASCII files are accepted, see [input](#) and [output](#) for more information. Even shuffled files can be used (where points are not in time order). Trajectory and attitude data are needed to achieve maximum accuracy correction or calibration, but not needed if the only goal is to scan, QC or register. Position/orientation files can be provided in Applanix SBET, Riegl POF, Leica SOL, Terrascan TRJ, or ASCII. GPS time can be in week seconds, day seconds, adjusted GPS, or a mixture. The software will convert to adjusted GPS whenever possible and also solve possible rollovers and ambiguities.

Calibration

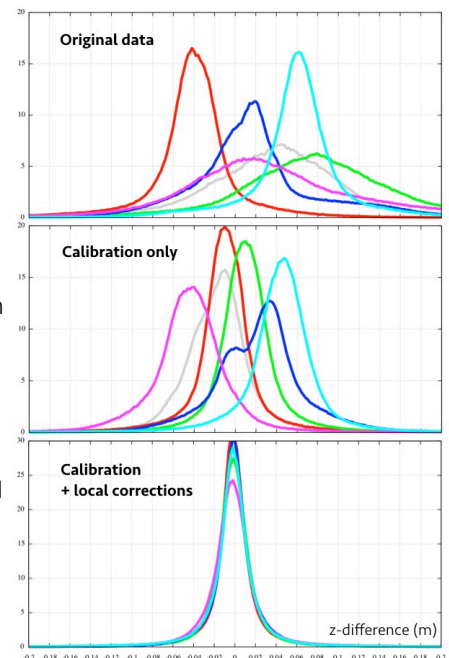
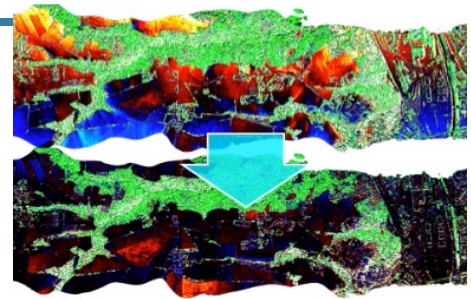
Systematic effects, such as internal geometry mis-calibration and distortions, boresight misalignment, and lever arm errors are automatically computed, before treating the random effects. Therefore, sensor calibration is not a prerequisite; if done, the software will correct for imperfect calibration. Classical calibration is also possible, with a cross flight, or at least three lines. This allows the user to estimate external and internal parameters (rigorous or generic).

HF IMU drift correction

Trajectory and attitude are adjusted for each swath to compensate low and high frequency IMU drifts. This is made possible by using dense point cloud matching regardless of the content, which provides enough information to compute 1 Hz or faster corrections. Important parameters involved in this complex (but fast!) inversion are determined automatically, and the user only needs to enter information relevant to the dataset, which can be very simple for standard configurations.

Multi-channel data alignment

Forward/backward looking or rotated scanners can be used (e.g. Riegl Q-1560) and processed together with the specific mount of each channel to achieve optimal accuracy during corrections, avoiding inter-channel discrepancies. Registration is done for the main channel and between channels to minimize computation time.



QA/QC stats and maps

Quality control tools are also provided for convenience. Relative accuracy can be checked before and after registration, and after final corrections are applied, before generating the corrected files which saves time. It can also be checked on arbitrary sets of swaths or point clouds without running any alignment. Grayscale TIFF or color JPEG Z-difference maps can be easily exported. Point density, customizable shaded relief, height and roughness maps are also available as options. Various text files can also be generated if desired, eg. swath footprints, bounding boxes, simplified trajectories; these files have an explicit header and can be imported into GIS software. Fast file scanning with optional PO and geometry validation is also possible and very helpful to spot issues before attempting more intensive tasks such as registration or correction.

Absolute control is also possible using ground control point (GCP) files. A user-readable file is generated summarizing the GCP stats before and after correction. There is an option to cancel the global Z bias between LiDAR and control data through a uniform vertical shift. The main reason for this capability is to address a fundamental limitation in boresight calibration (which cannot provide the z-lever arm). GCPs are never used to derive corrections otherwise, due to the high number of parameters involved in HF drift estimation and lack of reliability of individual GCP.



This is a command-line tool

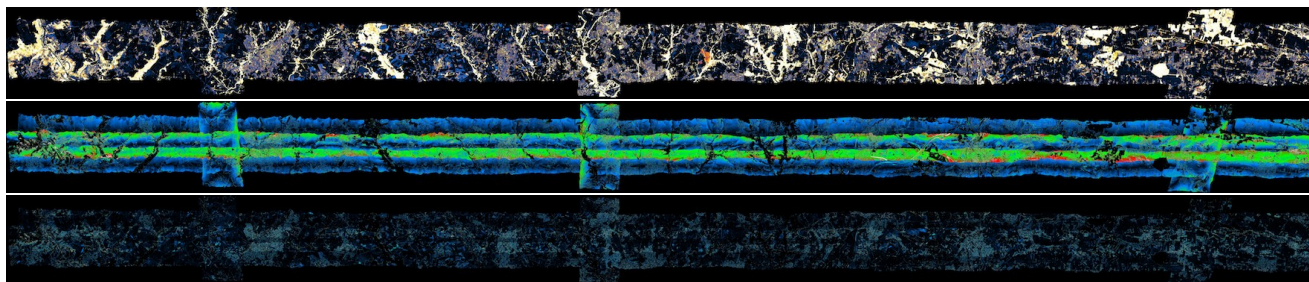
BayesStripAlign can run in a terminal (e.g. cmd or ConEmu on Windows), in a third-party external interface or in a batch file (.bat). Currently it has no graphical user interface, so double-clicking on the icon will not do anything, as the software requires to select at least the input dataset and some parameters.

Complex tasks can be achieved automatically with a simple command line, specifying the task, the input files, and various options. Good results can be achieved with default (missing) options in most cases so the command can be really very short. Commands can also be used in sequences in batch files, and invoked through high-level software interfaces.

Most parameters are optional, and have default values, so don't panic when you see the full list of options! Minimal command line examples are provided with each task type, and are often sufficient. Expert options should be used with care, or unpredictable results may occur despite all safeguards. Long options are defined for clarity, and one-character versions are sometimes available for simplicity. Persistent options can be stored in a configuration file and used systematically. Option files and file lists are also accepted to alleviate the command line.

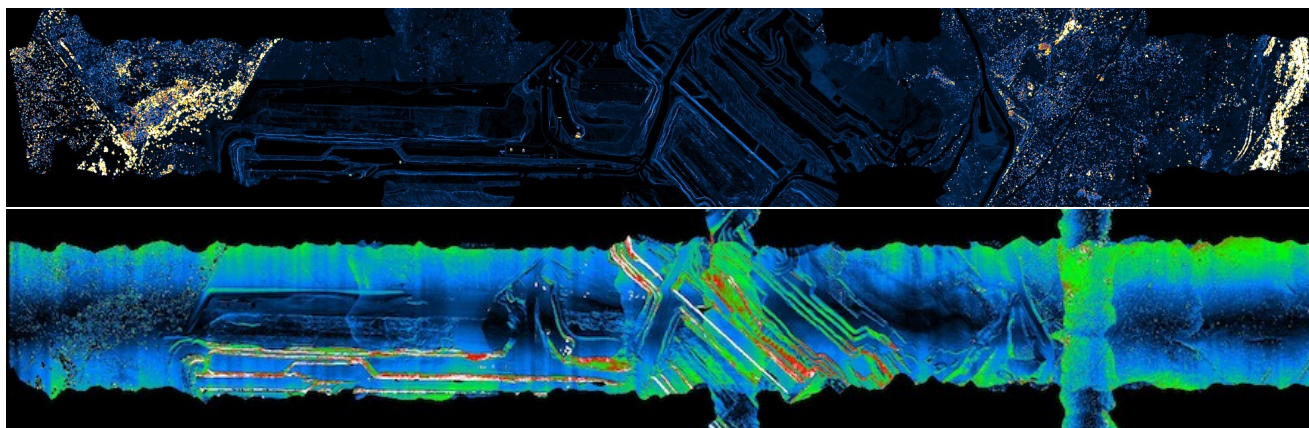
Current limitations

- For PO data in geodetic coordinates, built-in projections include Transverse Mercator, Lambert Conformal Conic and Albers Equal Area Conic; for all others the user needs to supply projected PO data in ASCII or TRJ formats. Geoid support for multiple countries is provided through NGS binary files (can be downloaded from the same location as the software). Attitude angles are not transformed during projection.
- Manual corrections always come with scan and tiling, which is usually a benefit but the data is read twice, which is slower than a simple correction. The purpose of StripAlign is automatic correction; manual adjustment is mostly provided for convenience.
- A UAV setting is available but the registration algorithm is not always suitable for small-scale UAV LiDAR data due to the content (complex topology, mostly vertical features) especially in built-up areas. A specific add-on will be available separately for UAV users in 2020.
- For internal sensor geometry, only linear scanners are fully supported for correction and calibration; elliptical scanners can be used but require splitting into forward/backward look angles and distortion compensation might not be optimal for those scanners.
- IBRC (intensity based range calibration) is not supported. Intensity information is not used. This type of calibration has to be addressed before attempting any geometric corrections with StripAlign or unpredictable results may occur.

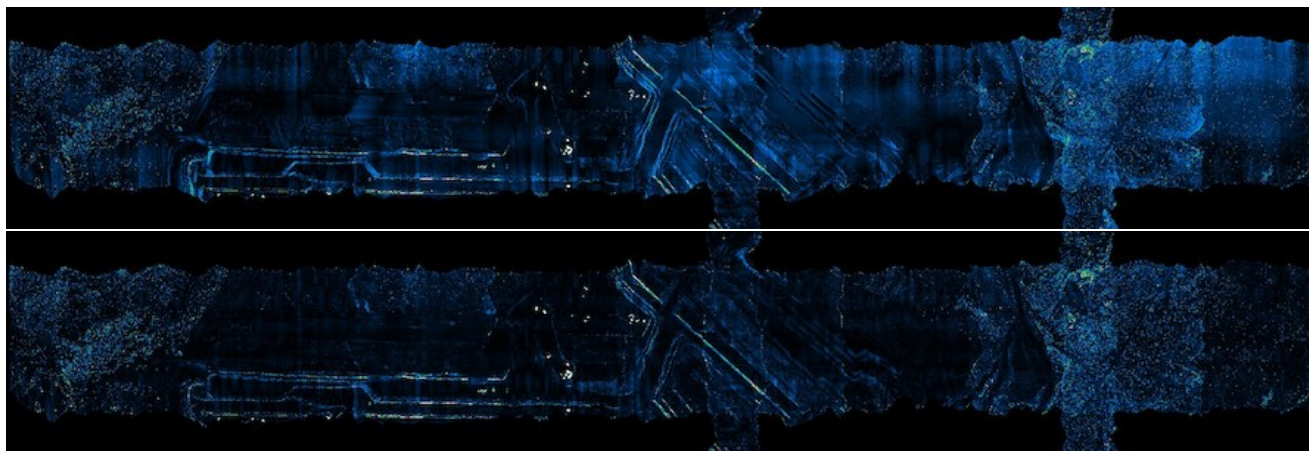


Registration of a billion point, 50 km-long dataset in 15 min (4 cores, 4 GHz) (usually difficult due to both low and high vegetation). 4 parallel, 3 cross lines, unclassified swaths.

Top: Roughness map reflecting terrain properties (different types of vegetation, building edges). **Middle:** original data DZ map showing up to 50 cm vertical discrepancies. **Bottom:** DZ map after registration, 1 cm residual RMS vertical error, same color map. A roughness filter is used to remove high vegetation and bad data automatically (black areas) and speed up registration.

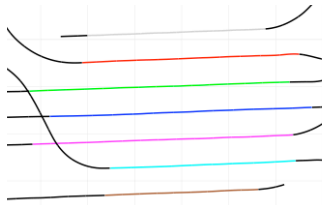


Part of a small dataset with cross-lines. **Top:** Roughness map reflecting terrain properties (different types of vegetation, natural terrain roughness and curvature). **Bottom:** original data DZ map showing up to 25 cm vertical discrepancies.

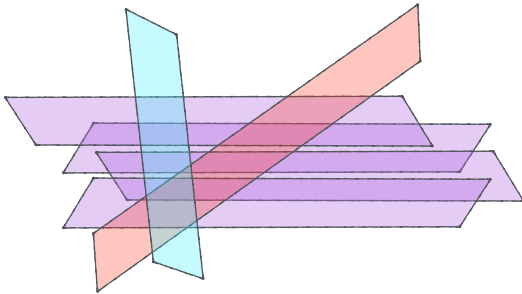


Top: Calibration (internal, lever arm, boresight) + Constant drift per swath corrections. **Bottom:** Calibration + HF IMU drift corrections at 1 Hz. The residual relative error goes from 2 cm to 1 cm RMS.

WHAT IS NEW IN VERSION 2.0?

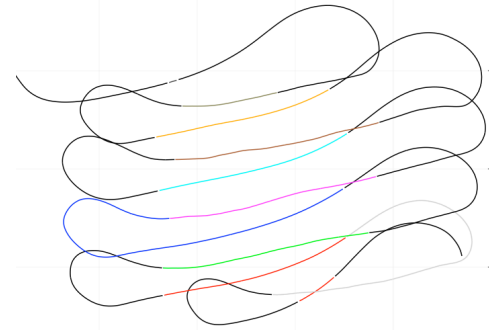


Typical trajectory required for version 1.3: straight AND parallel lines during LiDAR data collection (colored lines). No cross-lines allowed except for boresight calibration from small datasets.



In StripAlign 2.0 even curved flight lines are allowed during LiDAR data collection (colored lines); cross-lines can also be used if available. The tiling scheme is fast and effective and not dependent on geometry.

Trajectories don't need to be parallel anymore, they can intersect at any angle. Cross-lines can be used, and should be used if available, as they will help stabilize corrections or spot internal geometry issues.



Unlimited geometry

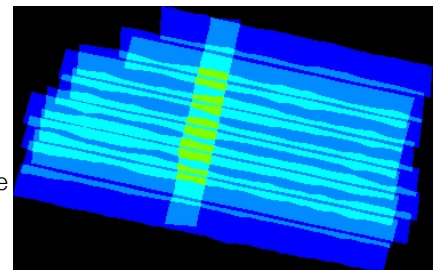
The major restrictions of version 1.3 have been removed, as the software no longer requires straight and parallel flight lines to correct large projects. Cross-lines should now be included as they help stabilize corrections and identify potential issues. Blocks or collects can be used all together, parallel or not. Now all tasks, from small calibration flights to very large multi-collect projects, are handled effectively thanks to a new spatial indexing scheme that stores no more than the LAZ size equivalent in a reusable cache. All steps involved in processing, from registration to inversion, have been rewritten accordingly.

Unlimited overlap topology

All possible overlaps are considered to maximize accuracy (in the previous version only the nearest neighbor intersections were used, which caused issues with lines collected as multiple swaths, so the user had to merge them manually). Multiple overlaps also help detect geometric discrepancies that might go unnoticed in a simple nearest neighbor topology without cross-lines. Due to the potential increase in computational complexity, options are available to restrict overlaps. Some of these options are activated by default to speed up multi-channel data registration.

Correction drift reduction, improved internal geometry

Correction drifts are unwanted large scale corrections that degrade absolute accuracy, usually occurring for large numbers of swaths. They are a side-effect of good relative error correction and will not show up on DZ maps or without GCP (but they can be detected on new image outputs). They are due to various biases, unexpected or improperly modeled, such as internal geometric distortions, and other complex effects. IMU error priors used in Bayesian inference are crucial in limiting the amount of correction, while allowing to compensate for relative errors, and their implementation matters.

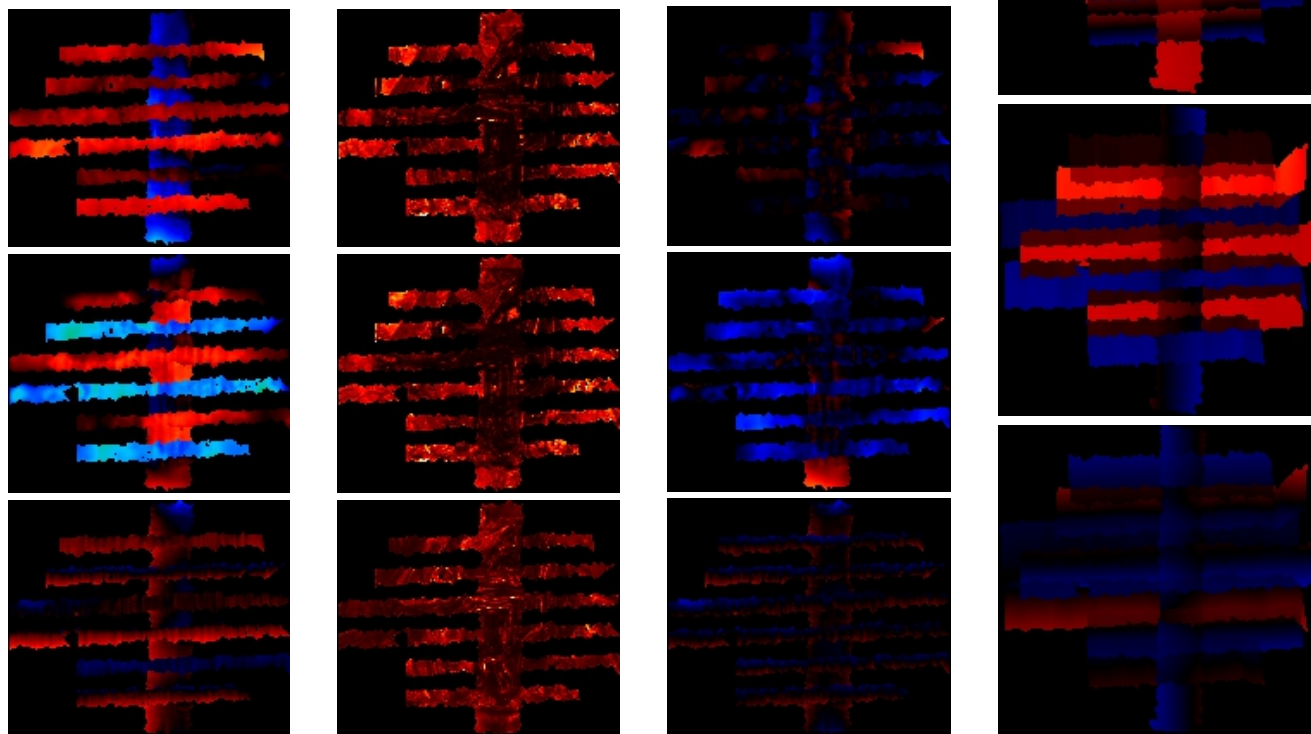


Overlap illustration (small image automatically written by StripAlign 2.0 during initial scan), showing how many swaths are available at a spatial location; all large enough overlaps are used for registration and QC.

A number of improvements helps make 2.0 more robust than 1.3 to such issues:

- Priors spatially distributed for optimum effectiveness
- New 6-parameter internal distortion models, both rigorous and generic
- Ability to let internal geometry parameters vary for each swath, useful with some scanners (initially one set per group)
- Large-scale, slow varying warp option acting as a subtle deformation field, effectively cancels the large-scale component of the mean correction field without compromising the relative accuracy improvement
- Mean correction vector cancellation, uniform component of warp, global shift only

Vector images from registration and correction



Vector images (top to bottom: x y z) written during registration.
Left: estimated displacement field, **right:** related uncertainty.
 Deformation maps can be used for diagnosis as a 3D QC tool.

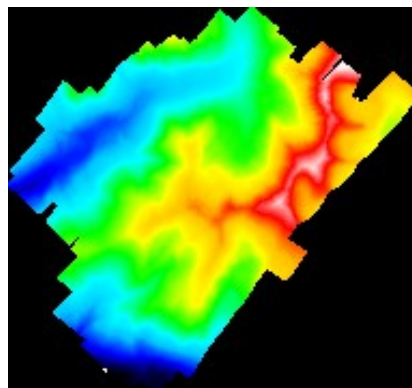
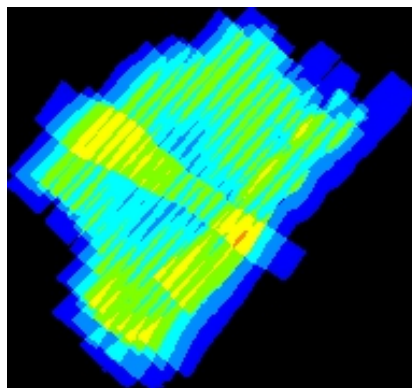
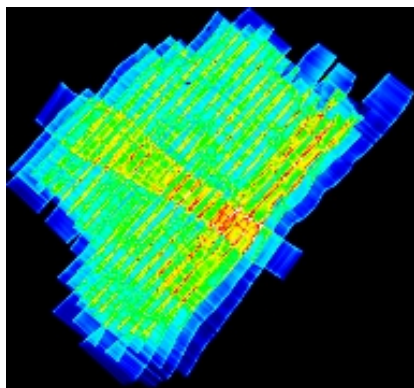
Vector images (top to bottom: x y z) written during correction.
Left: inversion or model fit residuals (showing potential issues).
Right: computed (and applied) corrections, mean represented here, max. also available (showing possible unwanted drifts).

Small vector images are saved to help visualize deformation fields and uncertainties from registration, corrections and residuals. Signed (mean) or unsigned (max) versions can be saved depending on options. Warp vectors are also saved if computed (not shown here, same dimension as correction images).

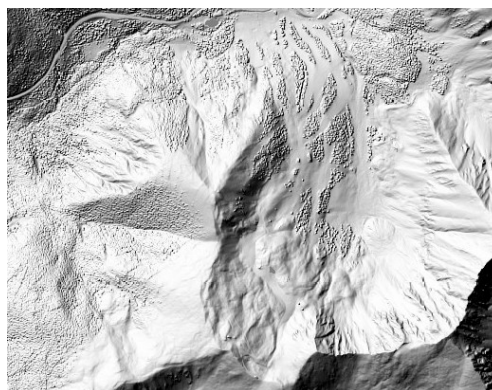
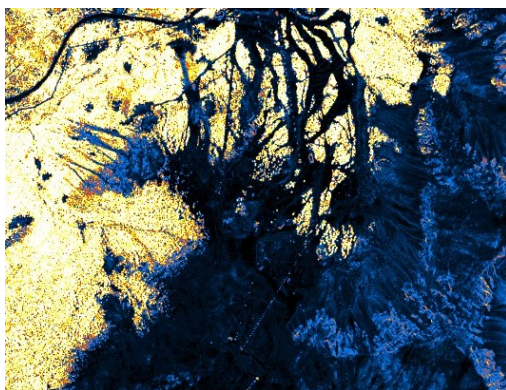


These images are useful for QC, to evaluate the full **3D relative geometric accuracy** from LiDAR data, and also to check that everything went smoothly (no large corrections or significant residuals).

More QC images and maps



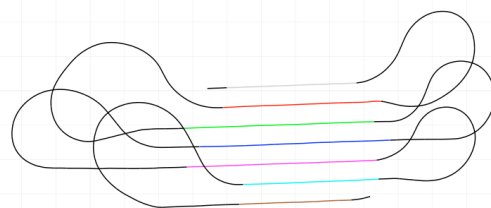
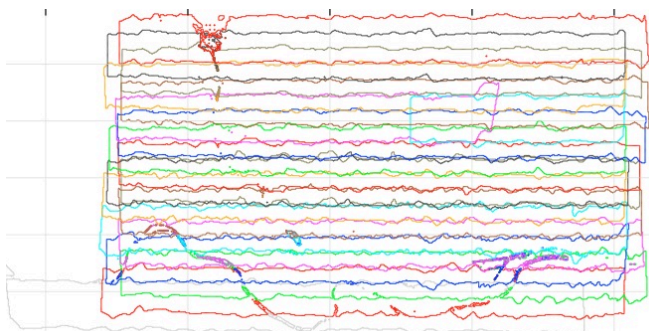
Point density, swath overlap and height images: small images automatically written by StripAlign 2.0 during tiling, prior to any processing. Group overlap images (shown on page 10) are also produced.



Larger maps: surface roughness and shaded relief, written by StripAlign 2.0 upon request during gridding, with any QC, correction or registration operation (options -rmap and -smap). Large point density map also available with -dmap. Now a subsampling factor with respect to the grid GSD can be set (default 4) to avoid very large files.

Enhanced statistics reporting and spatial data export (text format)

All exported text files have a simple explicit header row, and can be used in various GIS or plotting software. Log files are easy to read outputs (calibration parameters, various QC, LiDAR and PO statistics).



Left: color-coded swath footprints (intersection footprints also available). **Right:** subsampled trajectory footprint, color-coded swath number, useful to check LiDAR/PO synchronization and spot possible coordinate system issues. (All footprints are optional, exported with option -fp)

Performance improvements

The tiling and correction processes are now limited only by file I/O, multithreaded with a limited number of threads. The registration (usually the most time consuming process) is fully multithreaded, with a brand new algorithm that is more effective in parallel and uses more memory to achieve maximum speed. Other improvements have been made to gridding and QC speed. The inversion algorithm (which computes corrections from registration data) is brand new, and optimized to handle the large numbers of parameters necessary for HF drift correction applied to hundreds of swaths simultaneously.

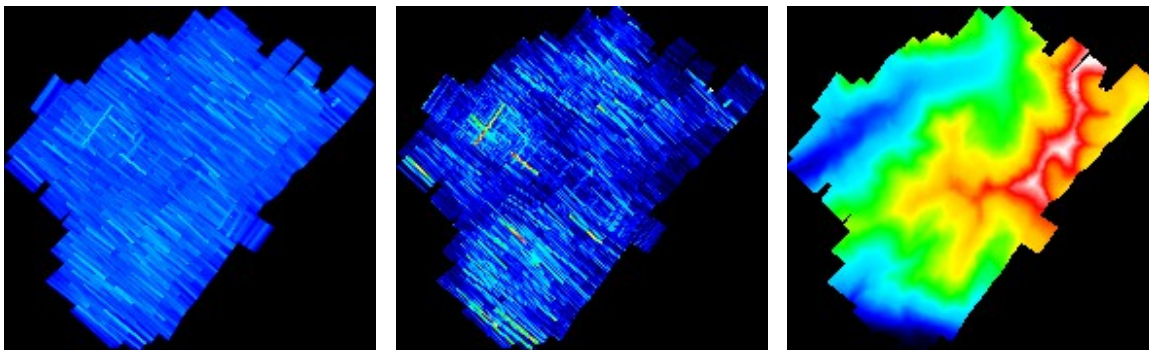
For a 10-billion points project in LAS with 15% sidelap (Optech Galaxy with SwathTrak), mostly parallel lines with a few cross-lines, the processing time is 70, 20, 60 and 75 minutes for tiling, gridding, registration and file correction, respectively (4 GHz core i7, quad-core, 8 threads, 16 GB memory, standard HD for data and SSD for temp. files).

Various improvements and additional features

- HF IMU drift corrections are now controlled by time period. The frequency can be as high as 1 Hz with current airborne LiDAR sensors. They are applied rigorously to trajectory and attitude (which can be exported after correction).
- The PO file reader is more robust with new features such as automatic rollover correction (week seconds and day seconds) and warnings for known format issues (ex. for Riegl POF and time formats). It also determines the time format and coordinate type automatically according to the format to avoid useless user inputs. The input is also simplified with a single option for all format (detected by extension). Radians have been added to ASCII format options.
- UAV scale projects can now be handled. Extra options were added to allow using UAV data (small scale, high density), so as long as the data looks like scaled airborne point clouds, the alignment should work just the same! QC will always work, but a UAV registration module will be required to deal with the specificities of small-scale objects (walls, pipes, trees etc.).
- The registration does not require PO data anymore. The advantage is that StripAlign can also be used for displacement estimation, to help analyze the geometric inter-swath accuracy in 3D (not only in the Z direction as most QC software). Vector images and stats can be conveniently used for this type of analysis.
- Additional scanning commands are now available to scan files with and without PO data, as a pre-check before more complex processing. Geometry validation has also been added, with automatic checking as well as stat file export. This helps find geometric issues (eg. multi-channel boresight angles, gross georeferencing errors) quickly. The software has a nested structure as shown on [this diagram](#), and allows fail-safe [multi-step processing](#).
- Point filtering based on LAS records has been updated to handle synthetic points. Grid cell filtering has been improved by adding a height filtering option so some water bodies and high points can be easily removed.
- Various new options are available to give more flexibility to the way groups are used for registration and calibration.
- Most Transverse Mercator projections (MTM, NZTM, LTM...) are now supported; the user just supplies an ASCII file with projection parameters in WKT format.
- It is now possible to repair or update LAS fields such as scan angle and GPS time rollovers, no registration needed.
- LAX (LAS index) files can be created on the fly upon request.
- PO files are no longer needed for fixed groups (groups containing only reference swaths that are not corrected).
- GCP reports are more detailed and include a processing string and group stats. Options are available for point weighting.

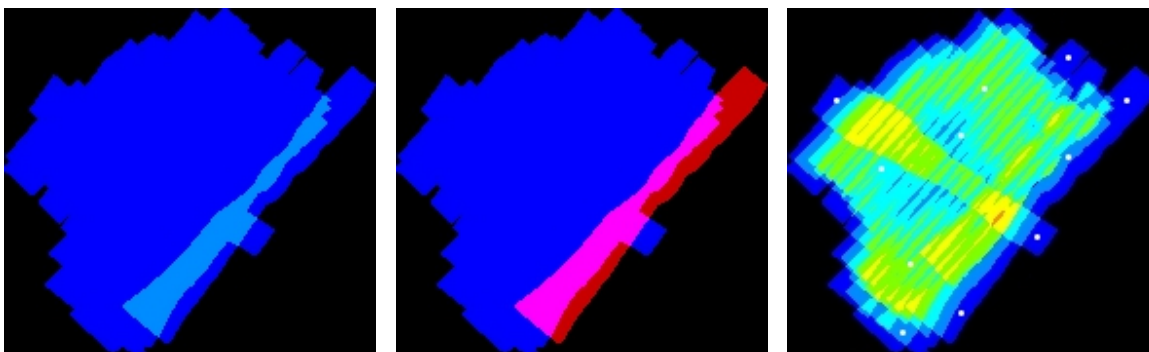
WHAT IS NEW IN VERSION 2.1?

Time interval, time deviation, robust height rasters



Microtile **time interval** and **time deviation** rasters (left and middle) and **improved height images** (right) with increased robustness to outliers have been added in 2.1. The Time intervals are used to determine the HF IMU drift correction interval automatically. Relative time deviation (or deviation from linearity) helps spot self-overlap issues and multi-channel mixing, which affect the ability to map locations to timestamps accurately, reducing the frequency of the computed drift corrections.

Group overlap, fixed/mobile overlap rasters, and approx. GCP locations



Group overlap rasters (left) show overlap between different groups (separate collects, different channels). **Fixed/mobile overlap** rasters (middle) show the extent of reference data in red (swaths, tiles etc. all merged into a single dataset) and mobile swaths in blue. Approximate **GCP locations** are added as white dots to all overlap maps when available.

Various improvements and additional features

- The period of HF IMU drift corrections is now computed automatically from the data (manual override possible).
- Simultaneous collects (eg. multi-channel) sharing the same flight line are now treated more rigorously and the PO data corresponding to each flight line are corrected accordingly. Only the input PO file names are duplicated but internally the flight line PO is shared between channels, yielding more consistent results and smaller corrections.
- Computed PO corrections can be saved as SBET if the input format is SBET. Otherwise flight line segmented ASCII files will be saved, in the same format as the PO data (geodetic or projected, deg or rad). This allows the use of corrected SBET files for more accurate georeferencing of photos or other non-LiDAR data. Option -opo needs to be added to export corrected PO data, and -po_tol controls the time buffer before/after LiDAR flight segments (when corrections are extrapolated).

- Point filtering has been extended to allow selecting first returns only: use `-last 0` to disable (default) last return selection. All returns, including intermediate ones, can also be used instead of last or first, by adding option `-keep_all`.
- Registration data is now saved as binary DUT (more compact, faster to read) and can be exported to ASCII if needed.
- TIFF z-differences can be saved in 16 bits with option `-dz16` and the range for jpeg and tiff can be controlled separately. Small images such as point density and height are saved in 16 bits to avoid saturation. This only applies when option `-tiff` is used and does not affect jpeg output.
- Due to built-in size limitations of tiff and jpeg formats, file size cannot exceed 4GB, with max 64K rows or columns. To address that, StripAlign now tiles large maps, and the tile size can be set with `-map_size` (default 32K).
- The LiDAR swaths can now be projected in Lambert Conformal Conic, so StripAlign now supports all major projections (most US state planes) through WKT files, allowing to use geodetic PO formats in most cases. WKT parsing is improved and can now read the unit (m, feet) so specifying feet manually with `-feet` is no longer needed when using the `-wkt` option.
- Support for geoids has been added, also extending the use of geodetic PO data to orthometric LiDAR heights in a simple and automated manner (no need to input an approx. geoid height). Geoid support for multiple countries is provided through NGS binary files (can be downloaded from the same location as the software) with option `-geoid`.
- A mathematical model update for the internal distortions allows to better model some of the biases and make them independent of laser boresight and therefore increases compatibility with elliptical and circular scanners (eg. Leica Chiroptera, Riegl miniVUX-1DL).
- A few adjustments and fixes helped increase the compatibility with UAV data (even if the official UAV registration module is yet to be released). Success has been reported in many cases including corridor mapping.
- Other minor improvements include `-daysec` to allow the use of day seconds, `-plot_po` to export binary PO data to ASCII, command `-las_read_check` to debug I/O errors, etc. LASlib was also updated to the latest version to support the latest v4 compression and fix a few minor issues.

Since version 2.12

- Support for PulseWaves pulse geometric correction has been added. Any PLS/PLZ file corresponding to a swath (same name and time format) will be corrected accordingly, if options `-opls` or `-oplz` are used.

Since version 2.14

- The LiDAR swaths can now be projected in Albers Equal Area Conic (AEAC) through WKT files. WKT parsing is improved for better robustness to spaces and spelling errors.
- The software can now handle large IMU errors for certain bad swaths (a few m) while preserving absolute accuracy, single step, fully automatic. To take advantage of this capability, use `-C0` to disable calibration.
- A manual time delay correction capability has been added with option `-t_corr` to handle PO/LiDAR delays due to sync issues.
- Exported ASCII files (including world files) now compatible with LiDAR data in feet when using new option `-out_metre 0`.
- Added option `-ics_rms` to increase compatibility with circular/elliptical scanners (use `-ics_rms 0`)
- The manual correction mode can perform GCP-based vertical corrections only (only swaths, PO and GCP file needed)

- All swaths can be corrected with option -a or -corr_all, including those without overlap; calibration parameters and other time independent parameters applied (simple copy if no correction available)
- ASCII polylines (footprints and bounding boxes) can be exported in OBJ format with option -obj
- Registration of data with very large misalignments (20+ m) improved with new option -init 0
- Added support for module-based licensing: airborne, uav, noreg, nocorr (resp. large scale, UAV, registration disabled, corrections disabled) and limits for the UAV-only license module (400 Mp, 4 km²)
- Other improvements include a more robust IMU error estimate, more accurate DZ map and GCP computations for large displacements, AGL limit updated to allow the use of mobile scanning data, performance improvements (tile and grid caches, ASCII file output), reduced memory requirements for calibration

Since version 2.15

- Split option for multi-beam scanners (used in UAV) or elliptical/circular scanners (both UAV and airborne). Swaths can be split into multiple channels (up to 4) according to scan direction, LAS channel, scan angle, user data, point source ID or LAS classification) with command -split.
- Added support for various time formats in ASCII PO files (useful for UAV) through the use of existing option -A (long version renamed -po_time). Now accepting also standard GPS, UNIX and UTC. Separate microseconds column can now be parsed with code "u" (option -po_parse).

Since version 2.16

- New license manager supporting cloud server-based floating licenses. Automatic checkout and checkin and n simultaneous runs supported (cloud container compatible). Node-locked licensing still available in special cases. See [installation](#) section.
- New time deviation rasters _dev computed during tiling (time std dev after linear fit, divided by time interval). Added time deviation stats to _sw_stat file and terminal output.
- Inversion prior improvements. Improved smoothness prior for areas where registration data is missing. Improved displacement RMS computation reliability for auto IMU prior.
- Gridding code update to handle depths down to 7500 m (for sonar point cloud alignment).
- Option -merge to put back together the swaths split with option -split, automatically during correction (see above).
- Option -rms_all to compute displacement RMS from all data instead of the default 95% confidence interval, for auto prior.
- Option -dev_max replaces -dt_max for microtile timestamp filtering. Uses time deviation (linear fit std dev divided by time interval) instead of time interval to avoid penalizing slow scanners (UAV, underwater). Option -dev_range controls the colormap of the new time deviation rasters.
- Option -mean to enforce zero-mean correction (disables internal z bias cancellation); previous option -mean renamed -drift_mean as it only affects the mean of time-dependent drift corrections.
- Various fixes: QC maps over 4 Gpixels, issue with -plot_po, IMU prior for high uncertainty registration data, origin of raster images, -nil ignored in some cases, ICS computation reliability, bounding box for UAV, drift RMS computation.

- Improved handling of reference swaths to enable the use of merged files or tiled data, by disabling timestamp processing for all fixed swaths, only keeping file time interval for logging and stats. Please use lasmerge with reference tiles!
- Option -large to allow very large projects (eg. corridor mapping) (up to 2000 km x 2000 km) without triggering an error.
- Minor improvements: added total RMS and number of points columns to DXYZ vector stat files for convenience, added summary stat line to most swath or pair-related stat files (DZ_stat, DZreg_stat, DZcorr_stat, DXYZreg_stat, DXYZcorr_stat, inv_stat), increased default number of I/O threads to 8 to reflect progress in hardware, showing % of microtile timestamps lost if above 1%, added explicit high level errors and warnings to help diagnose errors.

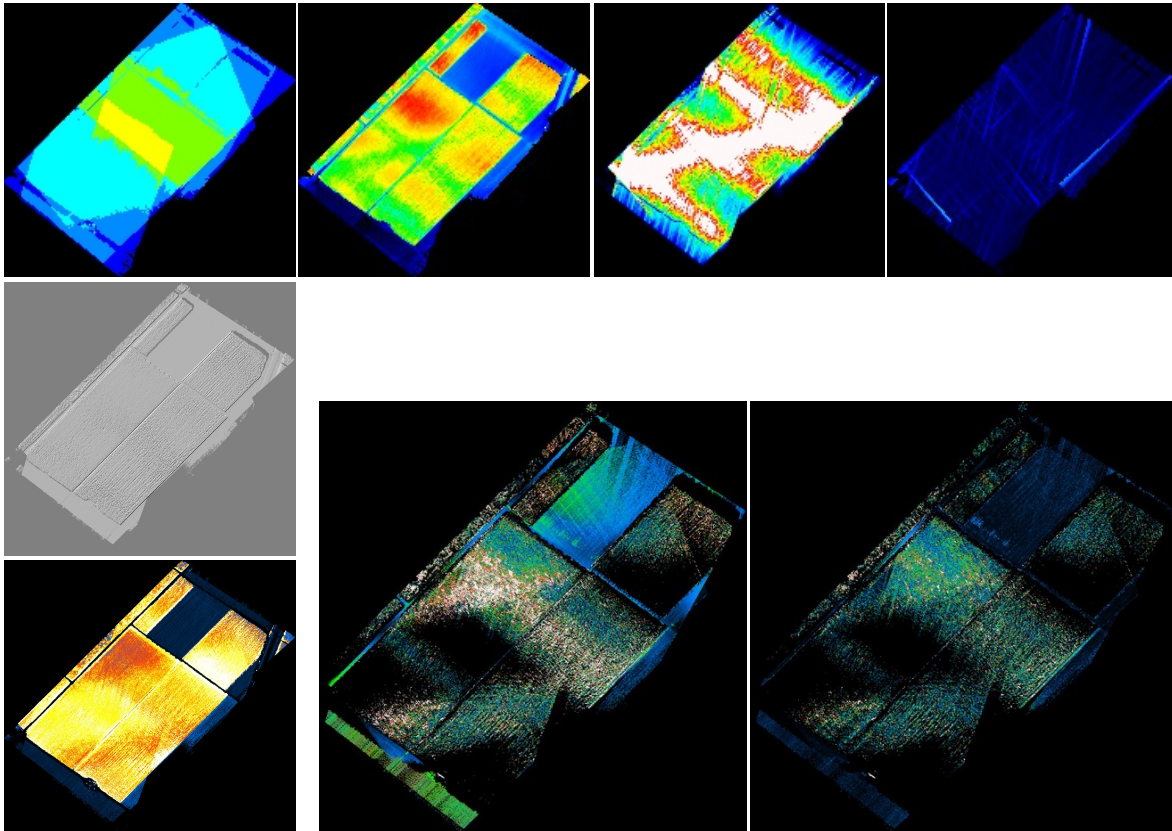
Since version 2.17

- Automatic channel splitting for multibeam UAV scanners, now split/process/merge in a single command line; options -split (existing) and -splitgrp (new) control how and which groups are split, and -split_mount (new) helps specify the mount files
- Recursive alignment in a single command with -align2, useful for large errors (airborne with IMU issues and sonar data)
- Global shift estimation from reference data allowing to translate the mobile data uniformly, thus correcting potential CS issues between mobile and reference dataset
- Merging all reference swaths into a single swath automatically for faster and more reliable registration, allowing to use tiled data as reference; registering reference swaths is no longer possible, and the DZ maps no longer include discrepancies in the reference data (except with fast QC)
- New raster _fov showing reference (fixed) data coverage in red, mobile data in blue, overlap in magenta
- Internal pitch angle export capability (see option -op) helps with multibeam sensors not with missing beam number data
- NED attitude angle parsing capability added to ASCII PO importer (default ENU convention), see [PO input](#) for details
- Using a tiff raster (+worldfile) as a "drop map" to filter out points during tiling, see [filtering chapter](#); all microtiles having at least one nonzero sample from the map are removed from tiling and any subsequent processing (gridding, registration), which helps exclude water bodies or temporal change areas effectively; new raster _drop added to output
- More robust solution for data with temporal changes: options -U3 and -U4 (-U1 and -U2 still supported)
- A number of new options were added: -splitgrp -split_mount -align2 -P -odir_1 -dz_range_1 -dz16_range_1 -v_range_1 -oposeg -shift_ref -op -ref_unc_max -Y -drop_map
- A major issue was fixed (olved a potentially serious drift issue affecting corrections using reference swaths, in certain conditions) and a bug in option -B (independent group Z bias correction) was also fixed
- Minor bug fixes (ASCII PO import, inversion, SBET export) and minor updates (GCP locations on overlap rasters, default calibration settings for UAV, -reg_ref removed, error messages and warnings)

Since version 2.18

- Major improvements to correction of **corridor projects** with limited overlap, increasing absolute accuracy (corrections are smallest possible given the data, without increasing relative error). Reliability and robustness of the inversion process have also been improved. Prior model redesigned to minimize total drift correction from combined position and attitude corrections. Recommended settings are -C0 (optional -fill 0) for single channel and -dcc 0 -int_nob for multichannel
- **Greater flexibility** of the HF drift model, with new options such as -fill (disables the smoothness prior in areas without data), -dcc (controls the constant per swath drift component), better handling of internal calibration when the constant component is disabled (manually with -dcc or automatically), -pitch (disables the attitude pitch correction separately) and -noz (improves inversion step 1 robustness in some cases)
- **Boresight calibration** is now disabled by default for single channel data and the main channel of multichannel data, due to correlation with attitude corrections. The default calibration strings are now B23456 and B3 for airborne and UAV. External calibration is **relative** by default (option -cal_rel controls this new behavior), so it only applies to secondary channels to solve inter-channel mis-calibration that flight line attitude corrections cannot compensate for
- For relative calibration purposes, the z lever arm component has been introduced (see option -C syntax)
- Improvements to **internal calibration**: option -int_sw is now on by default, as time dependence of distortions has now been reported for both Optech and Riegl scanners; enhanced prior model to better constrain internal parameters (same strength as drifts) and provide more robust results and fewer artifacts; new defaults (I1 disabled for airborne, only I3 enabled for UAV). new parameter I7 for generic model only (to capture the same nonlinearities as the rigorous model); parameter I6 (misalignment) now always unbiased regardless of option -int_nob, to avoid correlation with pitch
- Better **multichannel** corrections (especially HF component) and new option -ich to simply ignore channel info at correction level (if the rigorous approach is too constrained and corrections are still insufficient)
- Updated auto IMU prior and smoothness prior computation, and added option -abs2rel for increased flexibility so the user can control the absolute to relative accuracy trade-off if needed
- Added support for NavLab BIN format (Sonar data)
- Minor improvements: large corrections applied more accurately with extra refinement step (new option -refine); updated -op option implementation to compute internal pitch based on conical scan pattern (more accurate beam extraction from UAV data); increased robustness of std dev. estimation for QC and registration; improved reliability of time format conversion for long intervals; added correction vectors at GCP locations in GCP report for better absolute QC monitoring; increased range of -init to help with smooth Sonar data; added warnings about corrections higher than expected in overlap areas; -rms_all enabled by default to avoid (rare) issues; added pass/fail flag to BF/ICS geometry stat file
- A few bug fixes: corrected issue with -chgrp and reference data; fixed issue with single parameter calibration; addressed problem with option -X so that multichannel groups are now correctly processed; fixed bug with unix time format missing 0.5 s for leap years; fixed gridding issue happening with overlap gridding only and causing crashes due to missing temp. files; fixed slope normalization error related to GGSD in hill shade map computation; fixed large correction problem after inversion and only with -int_nob and -int_gen; addressed minor issue with non-overlapping swaths treated as references; fixed rare but critical inversion bug; improved handling of single swath calibration using reference data

Please read the release notes for the full list of updates, bug fixes and performance improvements:
groups.google.com/forum/#!forum/bayesmapsoft



UAV test with StripAlign 2.1 (see "No Sugarcoating: Sweet LiDAR from RiCOPTER carrying VUX-1UAV over Sugarcane" blog entry at rapidlasso.com). Top row, left to right: overlap, height, density and time interval small images. Middle left: hill shading. Bottom left: roughness (significant). Bottom large images: max abs z-differences before and after alignment.