

# America Makes Multi-Laser XML Schema (2020-03-23)

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## Important notes on scan files sent to LabVIEW

- LabVIEW expects to receive a single file containing all the XML layer files
  - The XML folder should be zipped and then given the extension “.scn”, e.g. mybuildfiles.scn
  - Other files, such as SVG visualizations, can be included in the zip file and will be ignored by LabVIEW
- Each layer is contained in a separate XML file
  - LabVIEW processes in order of filename, so by convention the first layer is named <project>\_0001.xml
  - Leading zeroes should be added based on the number of files expected so that files sort alphabetically in layer# order

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### 1. Use cases to be met by the new schema

These will be reflected in examples generated to accompany this document

- A. Single part built by **two independent lasers**, demonstrating use of **SegmentStyles**
  - a. Mark and Jump parameters are defined using the new SegmentStyleList section
  - b. Contours make up one Path, built by Laser1. Hatches make up a second Path, built by Laser2. Paths are processed **sequentially** (i.e. contours first, then hatches)
  - c. **SkyWriting** is turned on for contours (using mode 2) and off for hatches
- B. Single part built by **two lasers operating in Follow-Me** mode
  - a. Contours are built first, by a single laser
  - b. Hatches are then built by both lasers following the same path, with laser1 as Master and laser2 as Slave on a 60uS delay
- C. **Two parts** built by different lasers operating independently (concurrent build mode), utilizing **wobble**

## 2. ALSAM Multi-Laser Schema

Each XML file describes a single layer. See Definitions that follow for further clarification on these parameters  
The outline below indicates field names, formats and relationships

- ❖ Layer
  - Header
    - AmericaMakesSchemaVersion [yyyy-mm-dd]
    - LayerNum (optional) [integer>0]
    - LayerThickness [real>0, mm]
    - AbsoluteHeight (optional) [real>0, mm]
    - DosingFactor (optional) [real>0, multiplier on LayerThickness]
    - BuildDescription (optional) [free text]
  - VelocityProfileList
    - VelocityProfile (one or more sections)
      - ID [text]
      - Velocity [real>0, mm/s]
      - Mode [Delay, Auto]
      - LaserOnDelay [real or integer, microseconds]
      - LaserOffDelay [real or integer, microseconds]
      - JumpDelay [real or integer, microseconds]
      - MarkDelay [real or integer, microseconds]
      - PolygonDelay [real or integer, microseconds]
  - SegmentStyleList
    - SegmentStyle (one or more sections)
      - ID [text]
      - VelocityProfileID [text]
      - LaserMode (see note 1) [Independent, FollowMe]
      - Traveler (see note 2)
        - ID [integer. Not serial number, but a value to be interpreted by LabVIEW]
        - SyncDelay (see note 3) [integer, microseconds]
        - Power (optional) [real, watts]
        - SpotSize (optional) [real, microns]
        - Wobble (optional section)
          - On [0 or 1]
          - Freq [positive or negative integer, Hz]
          - Shape [-1, 0, 1]
          - TransAmp [real, mm]
          - LongAmp [real, mm]
  - TrajectoryList
    - Trajectory (one or more sections) (see note 4)
      - TrajectoryID [text, but usually an integer]
      - PathProcessingMode [sequential, concurrent]
      - Path (one or more sections) (see note 4)
        - Type [hatch, contour]
        - Tag [text]
        - NumSegments [integer]
        - SkyWritingMode [0, 1, 2, 3]
        - Start
          - X, Y [real, mm]
        - Segment (one or more sections)
          - SegmentID (optional) [text]
          - SegStyle [text]
          - End
            - X, Y [real, mm]

Note 1: LaserMode may be omitted if the segment style does not contain a traveler section, such as a "jump" style

Note 2: (omit Traveler section for Jump styles; otherwise include one or more Traveler sections)

Note 3: SyncDelay should only be included if the segment style utilizes multiple lasers

Note 4: Trajectories will be built sequentially in the order that they appear in TrajectoryList; one must finish before the next can begin. To build sections concurrently (using separate lasers), set them up as separate Paths within the same Trajectory and set PathProcessingMode to Concurrent

### 3. Definitions and notes

#### Glossary of terms (alphabetical)

Schema term	Description and usage
<b>AbsoluteHeight</b>	Absolute build height of a particular layer. Not evaluated by the code
<b>AmericaMakesSchemaVersion</b>	XML schema version, which LabVIEW uses to determine the appropriate parser
<b>BuildDescription</b>	Free text which may be used to indicate expected conditions or required capabilities, such as maximum power and velocity occurring in the build
<b>DosingFactor</b>	Indicates the depth of powder to be applied during recoat, as a multiplicative factor of LayerThickness 1.5 = 50% additional dose (1.5 x layer height)
<b>End</b>	Ending coordinate of the current Segment
<b>Header</b>	Collection of parameters which do not fall under the lists of velocity profiles, segment styles or trajectories
<b>LaserMode</b>	Defines the mode of operation when multiple lasers (Traveler sections) are included in a particular SegmentStyle. May be omitted when <2 Traveler sections are included within the style <ul style="list-style-type: none"> <li>Independent = multiple lasers operating on separate build segments. In this mode of operation, PathProcessingMode (below) is referenced for sequencing information</li> <li>FollowMe = multiple lasers traveling in synchronized fashion along the same set of segments: <ul style="list-style-type: none"> <li>The TravelerID having SyncDelay=0 (required) is the Master; all other (Slave) TravelerID sections must include a SyncDelay &gt; 0 in reference to the Master laser</li> <li>Each TravelerID can have separate power, SpotSize and wobble settings</li> <li>The indicated VelocityProfileID is used for all lasers, with the Master laser leading</li> </ul> </li> </ul>
<b>LayerThickness</b>	Indicator of the thickness of this build layer in the system's defined units
<b>LayerNum</b>	Optional numbering from bottom to top layer. Not evaluated by the code, so may be non-sequential
<b>Path</b>	Set of related scan paths (Segments) which make up a specific aspect of the build. Typically, a part should be divided into multiple Paths such that one path might include all the contours, and another includes all the hatches. All Segments within a particular Path should utilize the same laser(s) to avoid synchronization and timing issues within the Path. Parts can be subdivided into as many Paths as desired
<b>PathProcessingMode</b>	Determines how multiple Paths within a particular TrajectoryID will be sequenced <ul style="list-style-type: none"> <li>Sequential (default if omitted): Paths will be processed in the order in which they are listed. Each successive Path will begin building only after its predecessor is completed. This mode assures that the laser(s) used within a particular TrajectoryID are not subject to timing uncertainties (if the same laser(s) are used in multiple Paths) but may result in a longer build</li> <li>Concurrent: Paths will be built concurrently as permitted by laser availability. This mode will typically be used when each Path is assigned to a different laser. In general, any Paths which utilize unique lasers will be initiated immediately, but timing after any Path is completed will depend on the availability of each laser and cannot be guaranteed</li> </ul>
<b>Power</b>	Laser marking power in watts. If the TravelerID section is omitted from a SegmentStyle, Power will be set to 0 and the SegmentStyle is assumed to be a jump
<b>SchemaVersion</b>	Version of the AmericaMakes schema which was used to construct this XML. Formatted as year-month-date (e.g. 2020-01-27) of the date the schema was changed
<b>Segment</b>	An individual unit of laser mark or jump between two points. The first Segment in a Path begins at the Path's Start coordinate and continues to that Segment's End coordinate (which is also the starting point for the next Segment). The laser(s) which actually carry out the mark or jump are determined by referencing the SegmentStyleID: <ul style="list-style-type: none"> <li>If the SegmentStyle indicates one or more TravelerID's, these lasers carry out the Segment</li> <li>If there is no TravelerID listed in the SegmentStyle, the Segment is assumed to be a jump. Power is set to zero and the laser(s) used in the immediately preceding Segment carry out the jump. Therefore, it is improper to begin a Path with a jump segment unless the SegmentStyle specifies a TravelerID to make the jump</li> </ul>

<b>SegmentStyle</b>	<p>A set of parameters which defines a single mode of mark or jump operation. Each SegmentStyle must include a VelocityProfileID and may (optionally) include LaserMode and one or more TravelerID (laser parameter) sections:</p> <ul style="list-style-type: none"> <li>• Jumps may omit the TravelerID section. In this case the “jumping” laser(s) will assumed to be the laser(s) used in the immediately prior Segment within a particular Path. The laser’s Power will be set to zero during the jump. This may reduce the number of styles needed, since a single jump style can be utilized for all lasers</li> <li>• If LaserMode is omitted or set to Independent, only one TravelerID section should be included in the SegmentStyle</li> <li>• If LaserMode is set to FollowMe (synchronized), at least two TravelerID sections must be included. See LaserMode and TravelerID for further details</li> </ul>
<b>SegmentStyleList</b>	List of one or more segment styles. Only those styles included in the build’s SegmentStyleList may be referenced by the build
<b>SegStyle</b>	SegmentStyle ID to be applied to a particular segment. Name truncated to reduce XML file size
<b>SkyWritingMode</b>	Optional laser motion mode. If omitted or set to 0, will be disabled. See Scanlab RTC5 documentation for details
<b>SpotSize</b>	Laser spot size value in microns
<b>Start</b>	<p>Starting coordinate of the first Segment of the Path</p> <ul style="list-style-type: none"> <li>• All Segments are assumed to be contiguous from the End of the previous Segment, in contour fashion. Each Segment specifies only an End coordinate, rather than a separate Start/End for each Segment</li> <li>• To create non-contiguous hatches, set up alternating “mark” and “jump” segments by choosing a different SegmentStyles for each type of Segment</li> </ul>
<b>SyncDelay</b>	Indicates the delay in microseconds between a particular Slave laser and the Master laser in “FollowMe” LaserMode. Should be omitted if LaserMode is set to Independent or if the SegmentStyle is a jump. Each Slave laser’s SyncDelay is absolute with respect to the Master, independent of any other Slave lasers which may be synchronized to the same Master. The Scanlab RTC5 supports delays in increments of 10 microseconds only
<b>Trajectory</b>	<p>Grouping of related scan paths for one or more lasers</p> <ul style="list-style-type: none"> <li>• Each TrajectoryID may contain multiple Paths, which may each be processed by the same or different lasers as controlled by SegmentStyles and PathProcessingMode</li> <li>• If there are multiple Trajectories within the layer, they will be processed sequentially. The first Trajectory must complete before the second can begin, irrespective of the lasers used by each Trajectory. Any elements which are to be built concurrently should be included in the same Trajectory</li> </ul>
<b>TrajectoryList</b>	Contains all the scan paths for the layer. The individual trajectories will be built strictly sequentially in the order that they appear. Within a trajectory, however, individual paths (scan path groupings) may be built either sequentially or concurrently as defined by the trajectory’s PathProcessingMode value
<b>Traveler</b>	Section of a SegmentStyle which identifies and defines parameters for one specific laser. If a SegmentStyle utilizes multiple lasers, it should include multiple Traveler sections. Traveler:ID should be the system’s reference to a specific laser
<b>Type</b>	Indicates whether the Path consists of hatches or contours. Informational only; does not affect parameters
<b>VelocityProfile</b>	Metrics which defines a single mode of laser travel, including linear speed and various delays
<b>VelocityProfileList</b>	List of one or more velocity profiles. Only those profiles included in the build’s VelocityProfileList may be referenced by the build
<b>Wobble</b>	Optional mode of laser marking which adds an oscillating motion independent of laser travel speed. See Scanlab RTC5 documentation for details

## Notes

- i. An individual Path can utilize only one type of laser mode (either Independent or Follow-Me, but not both)
  - a. This could lead to resource and synchronization conflicts. It is up to the user to avoid this situation
  - b. If both laser modes are required within the same build, they should be set up as separate Paths
- ii. Unless the schema indicates there may be “one or more” of an element, that item can appear only once under its heading

- a. For instance, there must be only one instance of VelocityProfileList under the single Build entry
- b. However, multiple VelocityProfile entries (differentiated by ID's) may appear in the VelocityProfileList

The text below represents layer #5 from a very small build (a 1mm x 1mm cube) consisting of two contours and very widely spaced hatches. Line breaks have been added between major sections for clarity. See actual XML files for additional features such as wobble and FollowMe

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</TrajectoryList>  
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