Software Solutions for Manufacturing Excellence

Advanced Statistical Process Analyses & Control Environment

Real-time Quality Assurance

Web Dashboard

Reporting

Searches

Matching Charts

Normalized & Moving Charts

Add-ons & Chart Plug-ins

Combine advanced SPC with real-time performance

camLine
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LineWorks SPACE

LineWorks SPACE provides enterprise-wide Statistical Process Control (SPC) of process and measurement data for manufacturing

LineWorks SPACE manages hundreds of thousands of control charts in parallel, evaluating millions of measurements per day. Additional reporting, search, visualization, and analysis capabilities create a solid base to standardize manufacturing quality across all sites. According to ISO 9000 requirements for traceability, all data are managed in a centralized database. Many global companies rely on LineWorks SPACE to continuously improve their manufacturing process, to ensure tomorrow's quality, and keep a solid record of process history for customer audits.

Release 8.0 enables you to ...

- identify more root causes for OOC (Out of Control) events,
- sort data in charts to analyze dependencies,
- change each single SPC setting for a bulk of charts,
- stack calculated parameters on top of each other,
- see all control charts related to a specification,
- see the severity of OOC events in a chart image attached to notifications,

and more ...

Capture and Analyze More Process Context

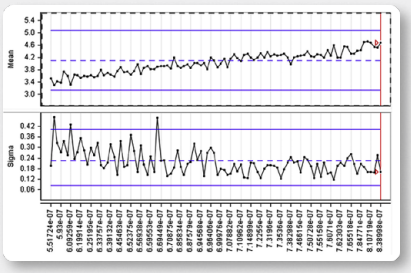
In LineWorks SPACE 8.0, the maximum possible number of extractor and data keys in an LDS (Logical Data Source) has been increased from 40 to 100. This additional data can capture additional potential root causes for OOC events, for example the tool, material or timestamps of process steps before the current one. A new function to sort samples in charts by these context values allows to screen for the influence of these explanatory variables on the OOC parameter. The sorting can be combined with the grouping by matching combinations. Date and time as well as numerical values stored in the keys can be used as sorting criteria.

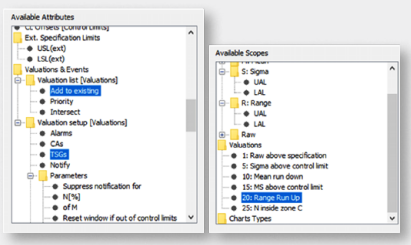
Fine-grained Paste Attributes

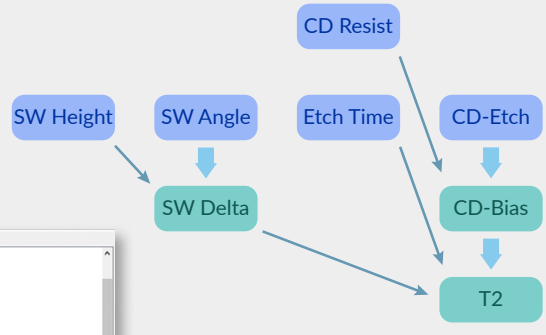
A new paste attributes dialog allows to select more than 100 individual attributes for bulk change operations. Individual filter keys, valuation settings or limits can now be transferred to multiple target objects. It is even possible to add, rearrange or remove specific valuations without affecting the settings of other valuations. The attributes are arranged in a tree so that complete folders can be selected for pasting related attributes with a single selection.

Stack Calculated Parameters

In LineWorks SPACE 8.0, calculated parameters can trigger further calculated parameters. This allows to integrate more complex black-box algorithms such as multivariate T2 control charts or machine learning algorithms implemented in different languages with pre-processing calculations implemented with standard SPACE calculation formulas or the ACO formula parser. Another use case is to split overly complex calculation formulas into several parts to make them more easily manageable.







Online SPC compares the context keys of the measurement data against the filter keys of hundreds of thousands of control charts and evaluates the matching ones by a definable set of SPC rules. LineWorks SPACE gives feedback within a fraction of a second and provides the results to operators, process engineers, managers, equipment, and MES systems. The SPACE Monitor supports operators by popping up violated SPC charts, asks for comments, and pulls up Trouble Shooting Guides together with a choice list of feasible Corrective Actions.

Dashboards are individually configurable. They provide up-to-date aggregated overviews of key performance indicators. For managers and engineers, dashboards support a fast access to the essential information by sorting, filtering, drill-down, and Pareto analyses.

Control Charts: LineWorks SPACE offers a wide set of configurable SPC charts including:

- $\bar{x}$, R, S, raw values
- Moving charts (MA, MR, MS)
- EWMA of $\bar{x}$, R, and S
- 1st differences of $\bar{x}$
- I / MR
- Levey-Jennings
- Attributive charts
  np, p, u, c
- Laney's p' and u' charts
- Deviation from normal charts (DNOM)
- Normalized (standardized) charts

Specification Limits can be managed within LineWorks SPACE in a hierarchical way, depending on user-definable context keys and independently of the SPC charts. A second set of specification limits can optionally be added at chart level.

If specification limits are already maintained in an external application, they can be submitted together with the data. There is no need to maintain them redundantly in different places.

Control Limits are calculated from data collected during an initial study. Alternatively, they can be entered manually in the charts' properties and even be protected individually from being overwritten by future re-calculations ("engineering limits"). Control limits can either be fixed or variable depending on the subgroup size. When limits change over time, the control chart will always display the true historical value of the changing limit at the time a subgroup was evaluated.

LineWorks SPACE is a real-time high-throughput system

The automated prerun feature of LineWorks SPACE can calculate and check control limits automatically as soon as enough subgroups are available and sends a notification about the outcome: new limits are accepted or rejected by the configured automatic sanity checks.

SPC Calculations: LineWorks SPACE supports control limit and ISO 22514-2 compliant process capability calculations also for non-normal distributions:

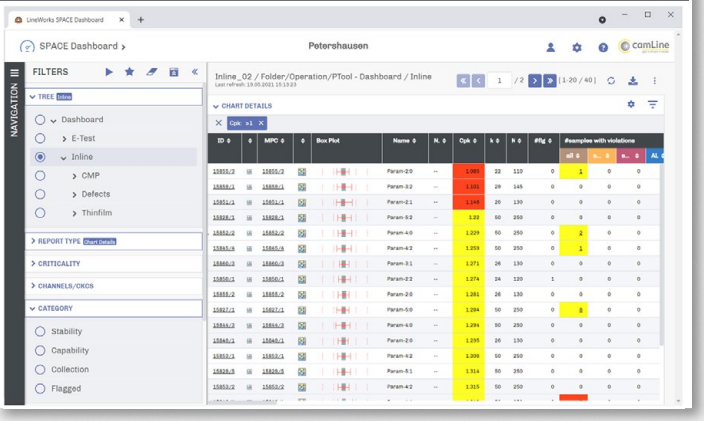
- Johnson SU, SB, and SL
- Log-normal
- Extended normal
- Weibull
- Gamma
- Gamma-Poisson (u-chart)

In addition to over 20 pre-defined calculation strategies, an extensible framework allows to plug-in custom calculation formulas and provide them with standardized settings as additional strategies.

Calculated Parameters: Incoming data can trigger the calculation of derived parameters from measurement data collected at the current or upstream process steps. A typical case is computing the difference of a quantity added or removed to / from a unit by a process step, e. g. the amount of defects added or the reduction of a layer thickness by polishing. LineWorks SPACE ships with over 20 pre-defined formulas for this purpose.

Custom Calculated Parameters : The Advanced Calculation Option (ACO) allows to plug-in additional calculation classes with arbitrary logic and even database queries. ACO also comes with a formula parser that provides additional functions and allows end-users to implement new calculation formulas without IT support.

Dashboard



↖ A dashboard offers fast drill-down features in a browser

Quality Assurance

Unit History shows all samples that are associated with given context keys such as specific lot, unit, tool, or vendor in a list by simply clicking the history button in the SPC charts.

SPC rules: there are currently 81 SPC rules which can be turned on / off and configured on individual chart level, including

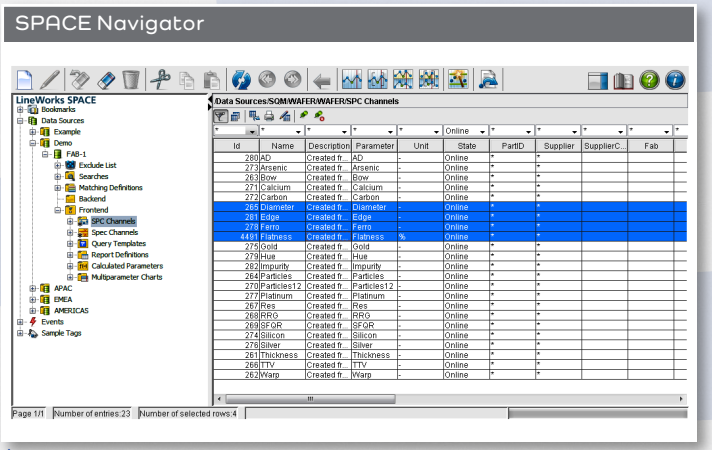
- Western Electric (WE) rules
- N% raw values out of spec / control / alarm limit
- Sample size to small
- Greenzone check after maintenance
- Maverick check
- 2-of-3, 4-of-5 rules for standard deviation
- Escalation rules for repeated violations

Charting provides graphical and analyses capabilities:

- Histograms
- Pareto of defect type, location or cause
- Point markers for
  - Violation (by type)
  - Comments
  - Invalidated data
  - Out-of-sequence data
  - Missing comments
- Configurable cursor info
- Tooltips
- Toggle buttons for
  - Spec / control / alarm limits
  - Invalidated data
  - Auto / manual scaling
  - Lin / log scaling
- Color data by grouping key (matching)
- Sort data by process context key

SPACE offers much more...

FDA 21 CFR Part 11 compliance
Measurement Data Archiving
Report Result Archiving
Free query charts and reports
Limit review wizard
Launch external viewers



↑ The SPACE Navigator represents the SPACE objects in a hierarchical tree

SPACE Navigator is the main user interface which presents the entire system of SPACE objects in a tree and offers multi-team oriented SPC administration. SPACE Navigator supports the automated creation and clear organization of hundreds of thousands of objects. Core features are:

- Nested folders, exclude lists, and chart templates
- Channels, CKCs, MPCs, Queries, Reports, Events
- Bookmarks
- Comprehensive search capabilities
- Quick table filter and sort
- Copy and paste object attributes
- Inherit object attributes to child objects
- View historical data in control charts
- View report results

Searches are stored permanently in the SPACE Navigator tree for repeated execution. They help find various objects and even individual samples based on user-definable conditions. You get more than 25 different conditions which can be combined to define individual search criteria.

Multi-parameter charts (MPC) are used to show multiple control charts of related characteristics, stacked on top of each other in one common window. For characteristics which are measured simultaneously, MPC can also be used for the online charts popping up in real-time in the SPACE Monitor.

Chart Link: violation mails and the Dashboard contain URL links which bring up the SPC chart in the Navigator, placing the cursor on the specific sample that was violated. A protocol handler starts the Navigator client, automatically if it is not already running. You can also embed the chart links in your own applications.

Reports: an automated reporting system generates cyclic reports such as daily, weekly, monthly, or quarterly. In overnight batch processes, mass data are continuously summarized to process indexes. They appear clearly arranged in the SPACE Navigator as different report types:

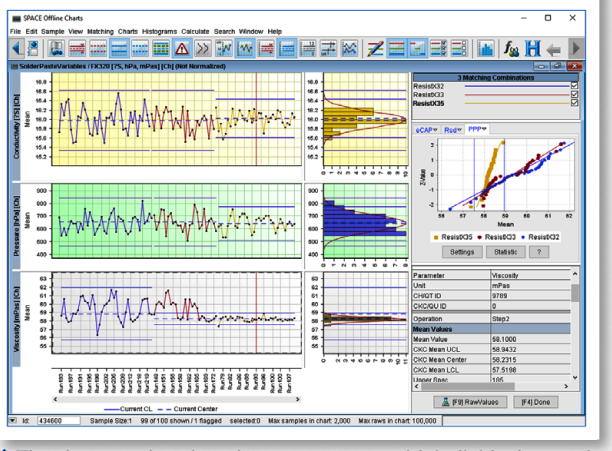
- Comparison
- Development (trends)
- Percentage development
- Development comparison

Advanced Quality Control for Industry 4.0

Cornerstone **Interface**: for advanced data and root cause analyses, LineWorks SPACE can export chart data to native Cornerstone dataset files which is Cornerstone's fastest format for reading.
To retrieve and reshape data for multivariate analysis, the SPACE-Cornerstone interface can aggregate and correlate data from different SPACE Charts into a wide table style dataset.

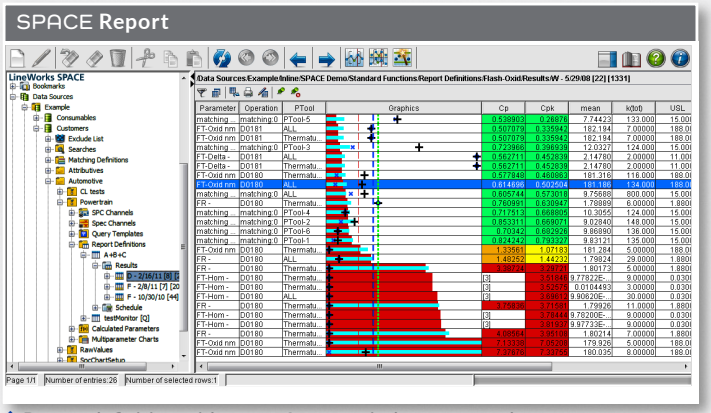
The Integration Kit enables customer input processes, event subscribers, and provides a management API for all SPACE objects. It comes with support and example programs for several middleware, programming languages, and platforms.
The integration kit also contains tools SPCTR and SPADE to extract, transform, and upload data from existing databases to LineWorks SPACE.

SPACE Multi-Parameter Chart



↑ The chart synchronizes three parameters with individual control limits (CKC) in matching mode to compare the behavior of three different processing tools.

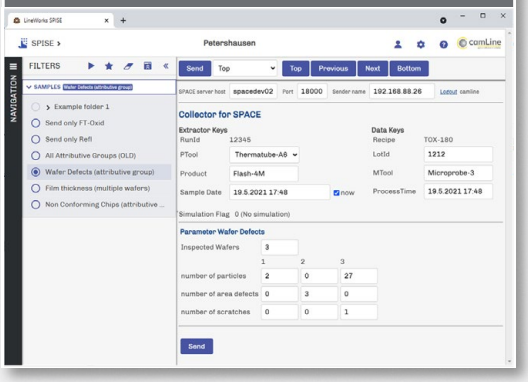
SPACE Report



↑ Report definition with a set of process indexes, report layouts, and scheduler

Engineering Analytics

SPACE Input Server (SPISE)

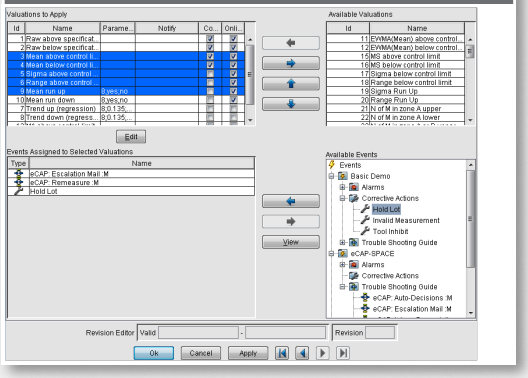


↑ Web-based manual data input with SPISE

The SPACE Input Server (SPISE) is a web server providing an HTML generator for manual data input forms:

- Validation of input against limits, formats, and missing values
- Supported data types: summary, raw values, attributive counts
- Link to Chart
- Optional user login protection

SPC Valuations



↑ SPC valuations handling offers 81 rules (incl. WE rules) that can trigger individual events like corrective actions

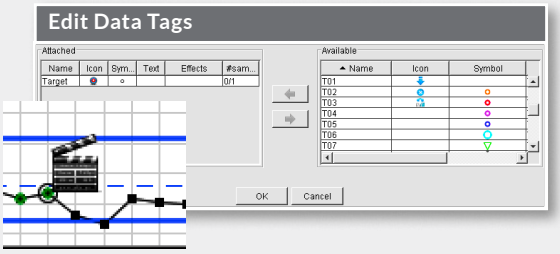
Out of control (OOC) actions are automatically triggered by SPC valuations handling and cause:

- Hold lot or inhibit tool through SPACE listener
- Operator instructions, Trouble Shooting Guides
- Mailing lists and mail texts
- Plug-in architecture for push notifications & SMS on mobile devices
- The optional add-on LineWorks SPACE eCAP provides a real-time corrective action workflow engine for LineWorks SPACE

Additional limits: Assign customer specifications to particular SPC channels, CKCs, or free queries. The external spec can be used to calculate "external" variants of process indexes.

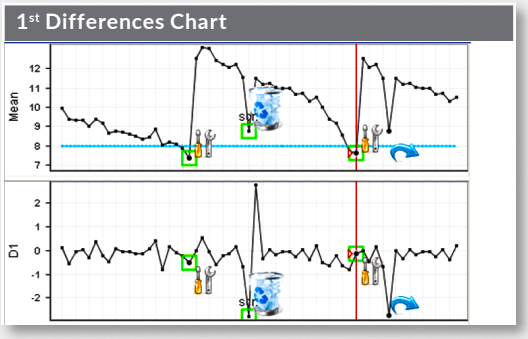
In addition to control limits, LineWorks SPACE allows to define a second, independent set of alarm limits on the $\bar{x}$, R, S, and raw charts which can be calculated or set as fixed engineering limits.

Edit Data Tags



Data Tags are user-definable SPC flags that can be attached to individual samples. The tags may draw your attention to special events such as tool repair, part replacement, or lot rework. You can define special effects and assign them to specific data tags. For example, reworked lots can be tagged and excluded from outgoing quality in your C_{pk} calculations for customer reports, but not for your internal C_{pk} reporting.

1st Differences Chart



↑ With the 1st Difference Chart, you monitor trend processes

1st Differences Charts are most useful for processes that exhibit a linear trend (e. g. tool tear and wear).

LineWorks SPACE Extensions

SPACE Add-Ons – Application specific add-ons extend LineWorks SPACE with smart business logic. They allow the flexible implementation of sophisticated requirements and customer-specific needs.

SPACE Chart Plug-Ins offer advanced analyses features directly at the graphical interface to operators and engineers. With ad hoc applicable correlation capabilities you will get more out of your data.

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