JetSoft
Data Solutions for NDT

Proposal

A roadmap to maximise automation in component inspection and to use the resultant data to drive efficiencies in manufacturing

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Executive summary

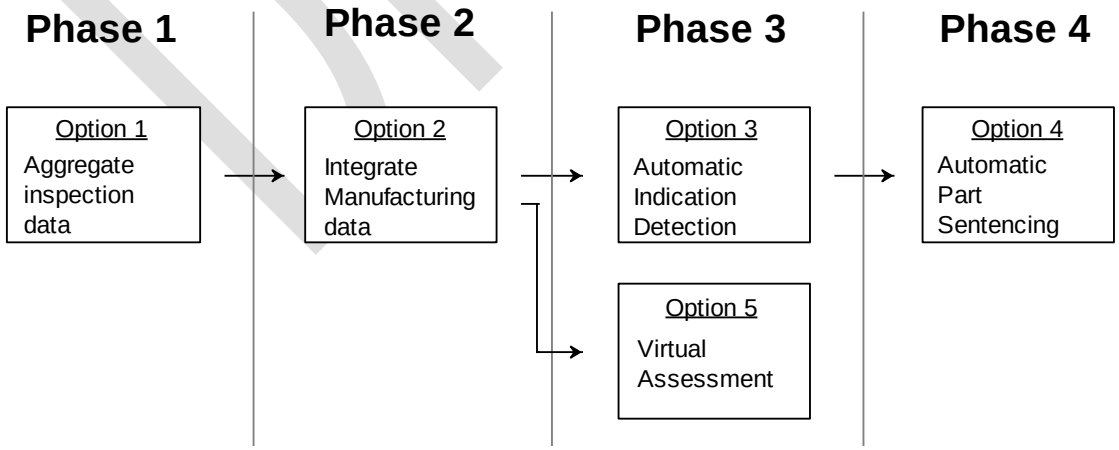
Effective test and product verification is an essential part of the advanced manufacturing process which determines whether a component meets the criteria to be considered air worthy.

Currently, test and verification is a laborious, expensive, time consuming task that is heavily reliant on human input. However, recent computational technological advances present the opportunity to automate much of this process, significantly reducing the cost of inspecting components.

These technological advances allow more than faster and cheaper inspections, with arguably the most important commercial benefit being derived from utilising the data collected during the inspection process. The techniques used to evaluate components create rich, valuable datasets, which encode all upstream activities. Using this information is key to taking an active, scientific approach to defect reduction and therefore waste reduction.

Additionally, test and verification data is vital for an effective digital twin. Accurate digital twins must match their physical counterparts as closely as possible to maximise their utility. This starts with understanding the as manufactured condition, as data gathered during inspection gives an accurate picture of the internal composition of components.

This document details a roadmap for a phased approach to implementing a system which not only maximises efficiencies through automation within the test and product verification department, but also exposes and utilises the data collated to be used throughout the manufacturing environment.



A phased approach to delivering automation to test and verification

JetSoft is a leading company that specialises in this area and has developed a suite of solutions to aid manufacturers to capture, manage and utilise their test data. Delivered worldwide, these solutions are actively being used in aerospace production environments to both make testing departments more efficient as well as driving changes in processes to significantly improve quality and reduce waste.

Following the roadmap detailed in this proposal will:

- Improve "right first time" and reduce waste through understanding the causes of defects and driving process changes
- Aid faster iterative continuous improvement
- Reduce variable manufacturing costs and increase yield by making intelligent decisions on the direction of components following each manufacturing process via virtual assessment
- Expose data in a form that can be used as part of a digital twin
- Introduce automation in a controlled and measured way to the testing department, reducing the human requirement for inspection, and delivering a faster more consistent evaluation

While each roadmap phase is fundamental to the next, each delivers significant benefit in its own right. This is not an all or nothing approach. Each option has been formulated to offer potential future advancements while delivering commercial benefits that justify the capital expenditure. Each phase is a combination of leveraging JetSoft's existing knowledge and applications with new developments that maximise benefits and integrate into [redacted]'s systems and working practices.

JetSoft is experienced working with large clients that have extremely sensitive data. All JetSoft solutions work on on-premises servers and data never leaves the security of the client's network. Users interface with the servers via an easy to use web interface, available on any device without the need to install any software. Licenses are sold in perpetuity meaning there is no ongoing operating expenditure**,** and support and maintenance is optional. The solutions allow unlimited users which are managed by [redacted], with dedicated roles and switchable feature access. Some features send out alerts and notifications at various times which are delivered by email to registered stakeholders.

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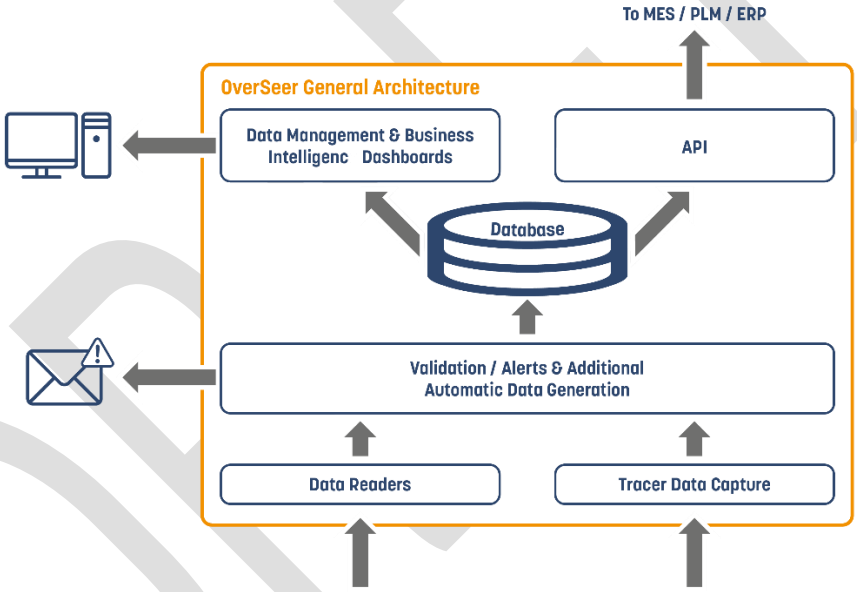
Option 1 – OverSeer, EyeView and Tracer
Prerequisites
None
Description
The effective collection and management of data is a key requirement for improving quality and verification processes in an advanced manufacturing environment. It is particularly important for the introduction of automation. Historically, data management has been challenging for testing departments, which use many complex inspection techniques and generate large amounts of technical data, often in proprietary formats. JetSoft's specialist solutions are designed to tackle this very problem, aggregating test data across inspection techniques into a single database. JetSoft are in a unique position to offer this due to their knowledge and skillset in software, data and testing, and through their partnerships with leading equipment manufacturers, enabling extraction of data from proprietary formats.      *The general architecture of JetSoft's data management solution* This option is to install an instance of JetSoft's OverSeer data management system, including EyeView and Tracer modules, at [redacted]. This installation will automatically read and catalogue inspection files, and provide tools for gathering manual inspection data, automatic report creation and a suite of interactive visualisations for business intelligence.
Features
Over time and from working with many advanced manufacturers, JetSoft has developed a feature-rich application that: • Automatically reads, extracts and collates data from many inspection formats • Provides a single interface to find, view, and manage inspection data across techniques

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- Integrates data from manual inspection techniques (i.e Visual, DPI, MPI)
- Delivers automatic report generation
- Enables real-time communication to stakeholders via alerts
- Includes business intelligence functionality, with interactive visualisations communicating quality statistics and performance metrics
- Has a user interface powered by web technologies for zero install use on any device and from any networked location*
- Can generate additional data at point of read. (For example, calculate porosity statistics)
- Supplies data to other manufacturing systems via an open database format
- Is capable of reading all inspection formats currently produced at [redacted]
- Captures and digitises data that previously was paper based or in a closed format (e.g. pdf)
- Unifies disparate data sources
- Collates and makes available inspection data for other industry 4.0 projects, such as digital twin.

Benefits

The advantages of OverSeer's data management features are two-fold: In the long term, they constitute the fundamental first step towards automation and the goal of "lights out" manufacturing. In the short to medium term, they deliver significant commercial benefit in themselves, including:

- Responsive search, filter and viewing tools provide fast access to data, reducing time overhead on key personnel
- Report generation features Reducing time required by operators to create non-conformance reports
- Generating new insights that be used as KPI's and to drive departmental changes
- Increases the department value proposition, as automatically generated statistics on quality can be delivered to other manufacturing departments
- Zero-install and connection from any device creates operation efficiencies by quickening communication between colleagues and enabling remote working*.
- The alerts system flags potential issues in real-time, enabling faster reaction and resolution and generally improving operating efficiency.
- Suppling understanding of equipment utilisation which can be used to accurately determine when new equipment is required as production volumes change.
- Makes data available in an easily accessible format for other projects

*All data remains within and never leaves [redacted] network. Connection is via on-premises web server, with integrated security, users and restricted feature access.

Scope and limitations

Budgetary cost indication

[redacted]

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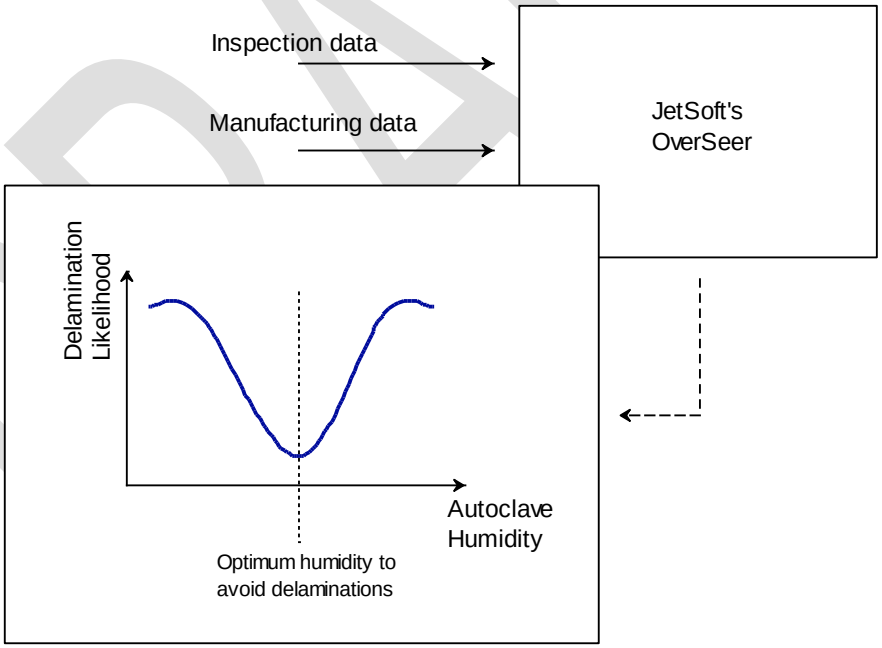
Option 2 – Manufacturing data integration
Prerequisites
Option 1 – OverSeer, EyeView and Tracer
Description

The composition and details of a component, and any indications or defects detected in inspection, are a product and result of upstream manufacturing processes. By the time a part is inspected, considerable time and resources have already been invested in the component, and they are of substantial value. Any defects discovered at the stage can immediately write off that value, and as such the minimisation of defects is essential for cost effective production.

Particular types of defects may have a common root cause, or result from a combination of process properties and conditions. Identifying the cause of defects is the first step needed to implement measures to remedy the issue, and prevent such defects from occurring in future runs.

Inspection data provides the essential pass/fail metrics for this analysis, but for maximum effectiveness, inspection data should be analysed and viewed in conjunction with data from upstream manufacturing processes, in order to track down the causes of defects, and other possible trends.



Analysis of inspection data with manufacturing data can diagnose the cause of defects

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JetSoft's framework is designed to accept and read data from other manufacturing processes and associate that information with inspection reports and data. This can then be viewed and analysed using JetSoft's business intelligence tools.

JetSoft currently has a system installed at an aerospace material production facility which is doing just this. By combining test data with manufacturing data, they are discovering the causes of defects. By targeting the most frequent and costly defects they have reduced their scrap rates significantly, for major cost savings.

An additional benefit of the system is the improved visibility of the effects of changing manufacturing processes, and how this affects quality. This is especially important for new designs or when rapid changes are being made to upstream processes, such as equipment changes or new suppliers.

This option is to develop the interfaces to integrate data from [redacted] other manufacturing processes into OverSeer.

Features

JetSoft will configure interfaces to read information from other manufacturing systems and join it with inspections data.

- Manufacturing information will be listed alongside inspection data
- Increased business intelligence functionality and interactive visualisation to cover manufacturing data
- Search and find functionality enhanced to enable users to find inspections based on manufacturing data

Benefits

- Reduce defects, and therefore waste and rework, by discovering the cause of defects through analysing manufacturing data alongside inspection data, and putting measures in place to prevent them
- Deliver continuous improvements faster, by quickly gaining understanding of how changes to upstream manufacturing processes are affecting quality.

Scope and limitations

- [redacted] to provide manufacturing data connections and detail data formats

Budgetary cost indication

[redacted]

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Option 3 – Automatic Indication Detection (AID)
Prerequisites
Option 1 – OverSeer, EyeView and Tracer Option 2 – Manufacturing data integration
Description

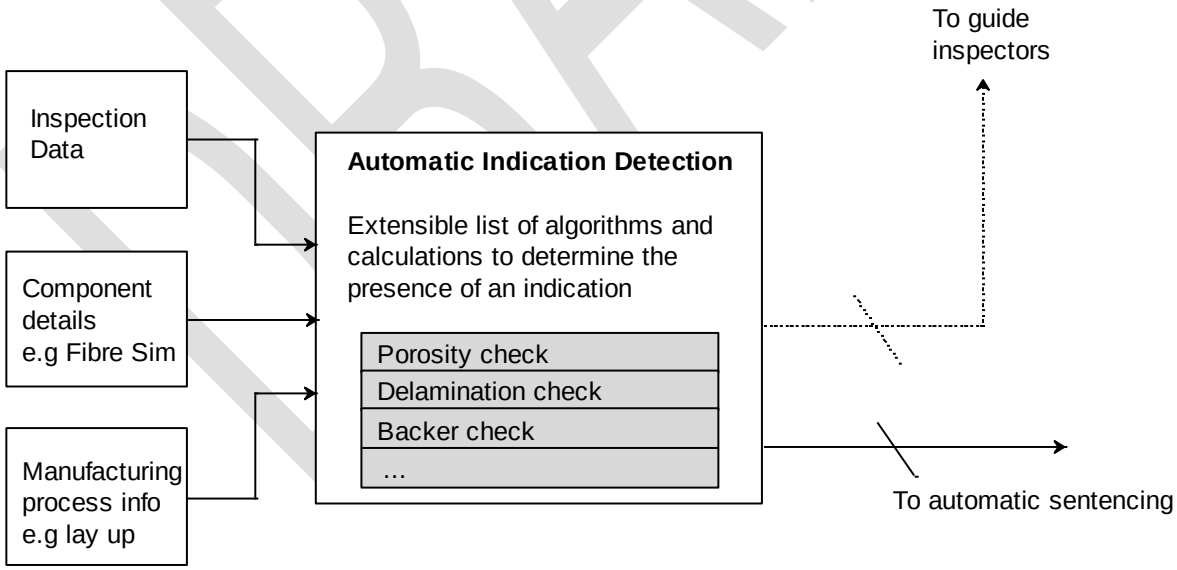
Automation of quality assurance processes is a challenging task, but has the potential for major gains in efficiency and productivity. Recent advances in artificial intelligence (AI) techniques are enabling applications in areas previously unfeasible for automated analysis.

Strict tolerances, and large quantities of data from modern inspection techniques can make assessment more time consuming and difficult for operators and inspectors. Automation of at least some aspects of the inspection process is therefore becoming both more viable and increasingly commercially attractive.

JetSoft considers the automation of test and verification in two stages:

- The first stage is automatic indication detection (AID). AID is the automatic assessment of inspection data to determine the likelihood that an inspection contains an indication.
- The second stage is Automatic Part Sentencing (APS). APS takes the discovered indication and evaluates against a defect specification to automatically determine whether the indication is a defect.

JetSoft previously issued a white paper to [redacted] entitled *JetSoft – Concepts for Automated Indication Detection*. This document discusses the requirements, features and benefits of an AID system.



AID performs an extensible list of checks using targeted techniques to find indications

JetSoft has a delivered an AID system, built following the architecture described in the concepts document, that is currently running in an aerospace production facility. The system is built not only to spot possible defects but other indications that may be of interest to other areas of manufacturing. This data is catalogued and tracked alongside all other inspection and manufacturing data and made available to all stakeholders.

This option is to implement an AID system at [redacted].

Features

- Automatic assessment of inspection data against an extensible list of checks
- Supplies data in near real-time to operator to aid defect detection
- Data catalogued for use in business intelligence tools
- Access to generated data for up and down stream processes
- Outputs have a weighting and administrators can set different tolerances, to maximise probability of detection (POD) rates
- Localisation features present the results of AID with any indications highlighted on the inspection image

Benefits

- Reduces time required by operator to detect indications
- Reduces likelihood of missed defects, by providing an independent assessment to be compared with operator results
- Goes beyond just pass and fail and automatically generates data which may of interest to other departments to aid in design and/or manufacturing processes improvements.

Scope and Limitations

- Initial list of AID checks must be given at the start of the project

Budgetary cost indication

[redacted]

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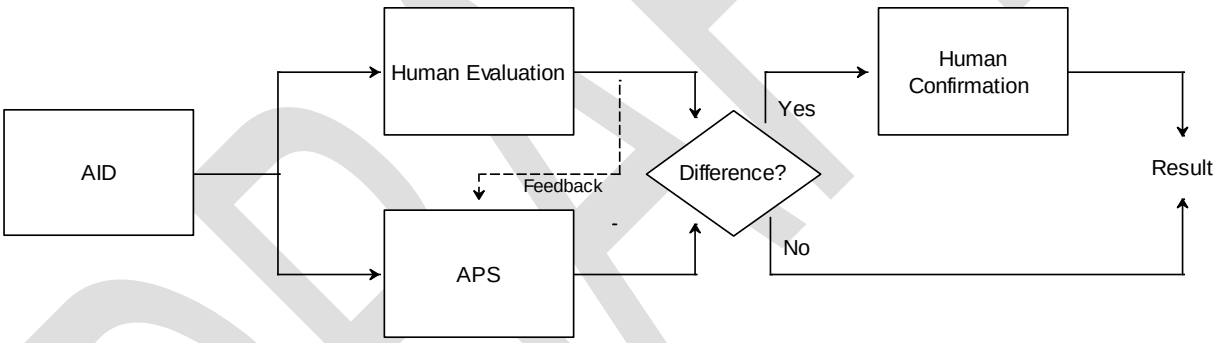
Option 4 – Automatic Part Sentencing (APS)
Prerequisites
Option 1 – OverSeer, EyeView and Tracer Option 2 – Manufacturing data integration Option 3 – Automatic indication detection
Description
The second and final phase of automating the inspection process involves taking the indication found by the AID module, and evaluating this against defect specifications to determine if the indication qualifies as a defect. While computational systems have the potential to out-perform human operators both in speed and quality, switching from manual evaluation to trusting an automated system is a major step. For this reason JetSoft recommends a phased approach where human involvement is slowly reduced. Initially APS will work in the background, in parallel with human inspectors. Any differences between the conventional evaluation and the automated system will be highlighted to users for confirmation of their findings.      *Integrating APS phase 1* Statistics on the APS performance will be gathered during this process, to both refine the APS and gain trust in its ability. In addition to determining the presence of a defect, the APS module will provide a confidence level, based on how clearly the assessment shows data is within or outside specification. As trust is gained in the APS system, the confidence level can be used to start automatically sentencing components. For example, initially we may decide that we can trust any APS results that have a confidence level of 100%, any lower and the data must go to a human inspector for evaluation. Over time we can start to reduce this threshold.

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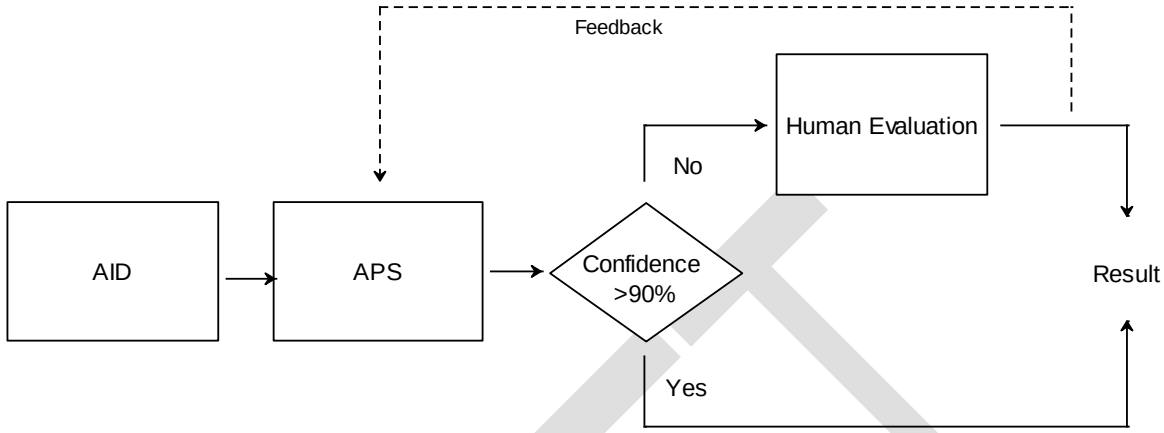

Integrating APS phase 2

This slowly removes the necessity for human evaluation from all but the most difficult decisions. It is not anticipated that human intervention will ever be fully removed from the process.

This option is to develop an APS system for [redacted] that takes the output from AID and determines the absence or presence of defects.

Features

- Takes AID output, measures the classified indications and compares with defect specifications
- Outputs the presence of defects, dimensions and confidence level
- Based on an administrator specified confidence level threshold output can be flagged to be viewed by an inspector
  - Different defect types can have difference confidence thresholds
  - System controls workflow and determines whether component can be released.
- All results and any interim logic stored for traceability and to be used for systematic improvements

Benefits

- Reducing the human requirement for inspection has significant commercial impact
  - Reduced required headcount
  - Faster decision making
  - More consistent results
- System performance continues to improve through feedback
- Tribal knowledge is retained within the system

Scope and Limitations

- Extensive time onsite and access to [redacted] experts to help write specification algorithms

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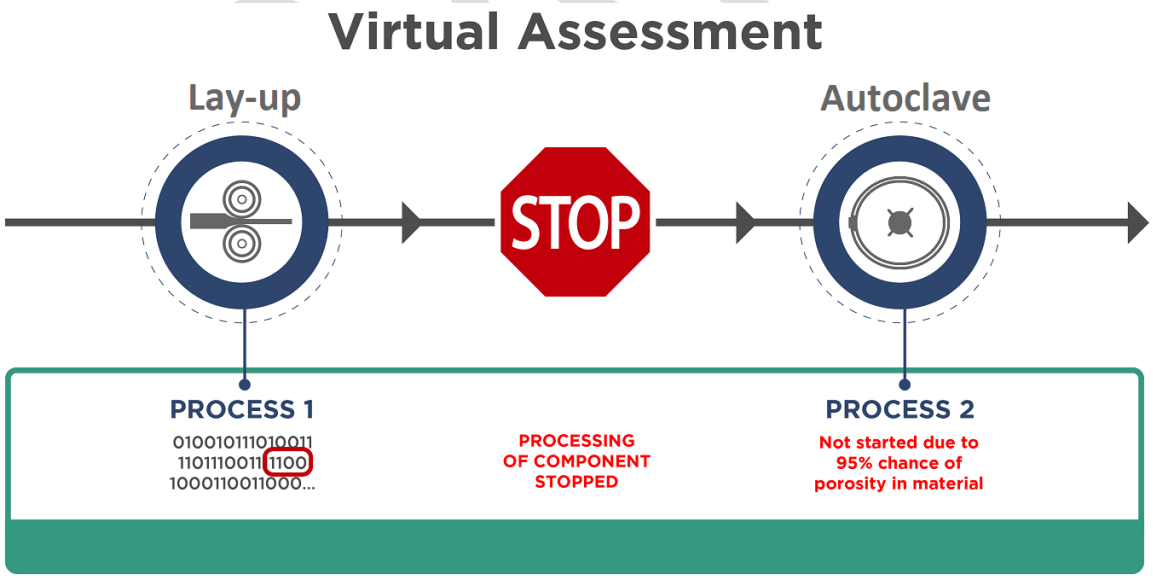
• Unproven, Jetsoft knows of no company that is using an automated system to sentence parts
Budgetary cost indication
[redacted]

Option 5 – Virtual assessment
Prerequisites
Option 1 – OverSeer, EyeView and Tracer Option 2 – Manufacturing data integration
Description
Test and product verification is usually one of the final procedures in the manufacturing process, however a defect found at test may have been caused by much earlier stage. That component, which is ultimately destined for scrap may have had value continued to be added to it, passing through costly manufacturing processes. If we can catch that defect earlier we can reduce the time and money spent on the component and so reduce waste and become more efficient and productive. Virtual assessment is a technique which compares data from early stage production processes, with historic manufacturing and inspection data, to determine a likelihood that components remain defect free at each stage. For example, historic data may show that parts which experienced particular conditions in the autoclave are significantly more likely to develop defects. Such tools allow field experts to make an informed decision on the future of components, considering whether additional early stage testing should be carried out, or if other steps should be taken. Preventing further work and resources being consumed on possibly defective material. The ultimate goal of this is to reduce factory wide variable manufacturing costs.      *Virtual assessment calculates the likelihood a defect is present after each manufacturing process* The latest techniques in AI and machine learning can uncover warning signs hidden in process data, which are otherwise difficult to detect. If the likelihood of a defect is found to be high, this can be addressed early. Resources and costs are

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saved by not progressing such a component through the remaining processes, which will ultimately be scrapped anyway.
Features
• After each manufacturing process the system supplies a figure of the likelihood that a particular defect has been generated. Calculated using historic data. • Users of the system can be alerted if this occurs • User defined thresholds for alerts • Enables data driven decision making following each process
Benefits
• Reduced factory wide variable manufacturing costs • Increased productivity • Improved asset utilization
Scope and Limitations
Budgetary cost indication
[redacted]