STEP-NC Enhances Value in Part Manufacturing

OMAC Manufacturing Work Group (OMW)

August 2012
STEP-NC Sub-Committee

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This document is published by the OMAC Manufacturing Work Group - STEP-NC Sub-Committee. Personnel from the following end user participating companies have reviewed the document content:

- Boeing Aircraft Company
- DaimlerChrysler
- General Dynamics Land Systems
- General Motors
- Louisiana Center for Manufacturing Science (LCMS)
- National Institute for Standards and Technology (NIST)
- Pratt & Whitney
- Rockwell Automation
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Executive Overview

In the current industrial production environment the exchange of product data is assuming ever increasing significance. Manufacturers who wish to react more quickly and cost-effectively to changing market conditions must make production information available as soon as possible across all areas of their enterprise. Moreover, they must ensure that this information can be processed, interpreted, and executed at any level of their geographically dispersed manufacturing facilities.

Data conversions, re-processing of incomplete format translations and data misinterpretations usually mean loss of time and money. Moreover, productivity, product quality, and critical time-to-market resources depend on a timely and accurate exchange of product design and manufacturing information. It has become essential to companies developing and manufacturing on regional and global scales to have universal and unified data formats and interfaces that span the enterprise from the engineering design workstation to the machine tools on the factory floor and back.

Integration of Computer Aided Design (CAD) generated geometry within the machining process requirements of Computer Aided Manufacturing (CAM) has progressed considerably. Today, many CAD/CAM suppliers provide applications that offer graphically-generated machining processes that are tightly integrated with the product design graphical models. With the evolution of 3-D graphics systems in both product design (CAD) and in the manufacturing process functions (CAM), manufacturing engineers and NC programmers have been provided with vastly improved tools to more effectively and efficiently generate cutter tool paths for machine parts and motion control for assembly processes. At the same time, the process for exchange of motion control instructions from the CAD/CAM system to the Computer Numeric Control (CNC) and machine tool has not progressed beyond the dated and limiting formats in the ISO 6983/RS274D standards.

With the development and introduction of ISO standard 10303-238, STEP-NC extends the STEP geometric data exchange standard into the manufacturing domain by defining a two way interface between CAM process planning systems and CNC control systems. Moreover, machining processes based on STEP-NC will finally close the loop from the machine tool back to the production machine planning process. STEP-NC
OMAC alleviates and stabilizes what has been the weak link in the CAM process: the NC program, which represents the interface between the manufacturing planning process and the machine tool control system.

Interoperability and common connectivity between production assets and other systems in a manufacturer’s supply chain is essential to achieving the increased responsiveness, reduced investment and operating costs, and enhanced quality of end products that characterize lean and efficient production operations. Collaborative machine tool systems, based on the STEP-NC specification can enable End Users across all manufacturing verticals to meet these requirements in areas ranging from “Buy Anywhere, Build Anywhere, Use Anywhere” to lower total cost of ownership of manufacturing assets.

This document addresses that fundamental information disconnect between the installed base of hundreds of millions of dollars worth of manufacturing machine tool assets, the operators, maintenance and factory support staff, CAD/CAM systems, and production planning processes that depend upon or manage them. The proprietary, vendor-specific nature of these assets has spawned a situation that affects all leading End User manufacturers who struggle to improve their ROI for new CAD/CAM systems as well as their legacy machine assets. Moreover, it will define and illustrate the basic value proposition associated with the adoption and implementation of the STEP-NC specification and AP-238 CNC feature set.

OMAC

OMAC, the Organization for Machine Automation and Control, is a global organization for automation and manufacturing professionals dedicated to supporting the machine automation and operational needs of manufacturing. OMAC has about 500 members from End User companies, OEM Machine Builders, Technology Providers, and System Integrator companies. OMAC currently operates two Work Groups: Packaging and Machine Tool. OMAC is a charter member of the Automation Federation (www.automationfederation.org). To learn more about OMAC, visit www.omac.org.
Develop Guidelines to drive STEP-NC towards meeting the needs of the industry End Users.

Work directly with Technology Suppliers (CAD/CAM and CNC/machine tool) in the development of STEP-NC AP-238 compliant controls.

Provide a limited production program of developed commercial products.

Globalize STEP-NC efforts for use on machine tools worldwide

Expand Lean Manufacturing methods and practices within the context of STEP-NC.

Work to enhance the capability and robustness of AP-238 (Multiple axes, Probing, new feature sets, etc.) and provide interoperability between application protocols (AP) for manufacturing.

Work to accelerate the development of an optimum commercial deployment.

**Scope of OMAC STEP-NC Sub-Committee**

**Integration of CAD with CAM Is Incomplete**

Collaboration and exchange of engineering design data has evolved to a mature technology, and today companies are able to develop product designs in a robust collaborative environment. Manufacturing process development, on the other hand, has traditionally lagged behind product design in areas of data exchange, integration with engineering design, and general collaborative capabilities.

A typical NC part program does not provide a useful format for production information exchange between design engineering, process planning organizations, and the shop floor. While data exchange for product design geometry has been universally accepted by nearly all CAD suppliers with the adoption of STEP, all too often the shop floor continues to deal with paper drawings and inadequate NC programming interfaces that were established over 40 years ago. The current CNC controller / part programming standard is based on the ISO 6983 global specification or the RS274D specification in the United States. This standard defines a set of M codes and G codes which specify a simple sequence of linear and circular movements as well as auxiliary instructions. Part programming based on this standard is fraught with bottlenecks and workarounds which
often forces the NC programmer to, for all practical purposes, re-design the part in order to produce it.

**Missing Link Between Manufacturing Process and Machine Control**

There are a multitude of operations and methods that need to be defined beyond producing a part program that defines a cutter path, drilling instructions, or an automated motion routine. A typical machined part, for instance, could require other complex functions such as collision avoidance for fixtures, variable tool path generation based on changeable tooling, and general set up information. Additionally, raw stock sizes, work piece geometry and orientation, and set up dimensions for the machine tool are also needed. Typically, an operator’s document would accompany the NC program to detail collateral information required by the operator such as a cutter list, work piece set up and orientation, Direct Numerical Control (DNC) information, cutting depths, and optional feed and speed information.

In today’s machined part production environments, these scenarios represent the “as is process”. Most of this information resides in the domain of the CAD/CAM systems, supporting on-line systems or in paper documents. The CNC for the machine tool generally does not have access to this information, consequently most of these necessary functions for the production process must be realized during the production planning phase and are not available at runtime on the machine tool.

Changes almost always occur once the part program gets into the tool try-out / production phase and reaches the shop floor. In the current environment, very little, if any, of conventional part programs can be changed and updated at the machine tool. Simple changes like variations in clamping positions, size of raw stock, or adherence to tolerances can require modification of the process plan, or worse, the part program. All re-programming and data manipulation that are due to part configuration changes have to be done at the CAD/CAM application and processing planning level. Furthermore, each part program is bound to a single machine and cannot be used on different machine tools, nor can the program be used for the exchange of information between process planning, work preparation, tooling, and other production processes. All of this adds considerable time and cost to the production lifecycle of a machine part.
**STEP-NC Provides Link Between Part Program and Machine Tool**

STEP-NC is a complete departure from the G and M codes based on RS274D and the necessity to generate a post-processed cutter path unique to the motion attributes of each machine tool. In contrast to conventional NC programming methods, it is based on exchanging and processing characteristics or feature sets that represent specific machine part attributes such as pockets, holes, profiling, face milling, bosses, along with the necessary auxiliary machining functions. STEP-NC not only eliminates the costly and inefficient process of generating post processors, but also establishes a collaborative environment for the exchange of information between product design applications, manufacturing process planning, and the machine tool on the factory floor.

The major caveat to this scenario is that the CNC suppliers will need to adopt STEP-NC and integrate AP-238 interpreters that can convert the attributes of each feature into direct motion control commands for the machine tool. Included in the general category of motion control beyond

<table>
<thead>
<tr>
<th>Application Protocol</th>
<th>Description</th>
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<tr>
<td>203</td>
<td>Configuration Controlled 3D designs of Parts and Assemblies</td>
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<td>213</td>
<td>Numerical Control Process Plans for Machined Parts</td>
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<td>238</td>
<td>Process Machining Features for CNC systems</td>
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<tr>
<td>242</td>
<td>Unification of 203 and 214 to include tolerance and other Product Manufacturing Information (PMI)</td>
</tr>
</tbody>
</table>

**STEP-NC Protocols for Discrete Manufacturing**
CNCs would be General Motion Control (GMC) and Robotics. While the AP-242 generally covers the requirements for machined parts, and the AP-238 addresses this machining process on the controller, robotic motion is most certainly a candidate for a STEP-NC application protocol that addresses kinematic robotic arm manipulation. Additionally, the CAD/CAM providers will need to be STEP-NC compliant by integrating AP-238 feature sets translators that output cutter paths based on the attributes of these features.

STEP-NC represents a manufacturing process standard that enables the use of the digital product model as machine tool input. Furthermore, STEP NC allows a complete database of machining information to be built around it. The machining process database contains the repository of feature sets that define the capabilities that must exist in the machine tool controller to cut the part. STEP-NC feature sets capture the entire machine planning process, including motion instructions and the working steps of each operation to be executed.

### STEP-NC Value Proposition For End Users

The purpose of this OMAC STEP-NC Value Proposition document is to identify and classify the issues, constraints, and values common to End User manufacturers within the machine parts production process that pertain to the exchange and interoperability of data required to drive motion control for CNCs and machine tools. The STEP-NC machining feature set specification, and more specifically the AP-238 application protocol which defines these process features for CNC systems, will be assessed to demonstrate the inherent value that the adoption of STEP-NC will bring to current machining processes.

### Manufacturing User Community Identifies STEP-NC Benefits

Users across a diverse range of industrial verticals have identified benefits that can be derived from the adoption and implementation of STEP-NC. These benefits can be categorized into specific areas and include:
Integration of emerging technologies

STEP-NC inherently relies on and subsequently promotes the concept of interoperability between product design systems, manufacturing systems, and throughout significant segments of the Product Lifecycle. As emerging technologies are adopted and implemented, such as PC-based control systems, Web-based machine tool collaboration, the concept of universal exchange of common machining interfaces via STEP-NC and industry specific application protocols (AP 214, AP-238, etc.) merges well with the overall focus on interoperability.

STEP-NC Helps Throughout the Product Development Lifecycle

Benefits can be derived throughout the product development and production processes with the use STEP-NC to streamline the feed-back of information that augments product improvement. The benefits of STEP-NC are compelling and have been verified by independent studies by Lockheed Martin and other manufacturers. STEP Tools Inc. has estimated, based on their Super Model Project, that STEP-NC can reduced the machine planning process by up to 35 percent. This is due to a significant reduction in drawing information usually generated for producibility. Additionally, STEP-NC can increase the task of cutter path generation up to 35 percent faster because less information has to be defined since 3D features are reused. And lastly, mid-sized machining jobs can actually be completed in 15 to 30 percent less time since STEP-NC provides automation computation for feeds and speeds compensation. Additional benefits can be derived from being able to reuse data more often, and from the controller being intelligent enough to prevent errors, optimize operations and dynamically re-create tool paths.

This also includes the progressive development of machining process feature steps to enable:

- Improved resource utilization for both machine tools and operators.
- Elimination of non-value added steps.
- Addition of new feature sets and steps that are derived from process improvement.
Data Exchange

The area constitutes the overall benefit of a common data exchange and interoperability environment that enables collaborative production processes between machine parts planning and programming and the machine tool.

- **Data Retention:** STEP-NC will make possible a database of machining features that can be retained and stored to facilitate as-built part configurations for future use.

- **Robust feature set files:** The AP-238 specification for CNC driven machine features is a dynamic file collection that will grow to fit the machining requirements of the users.

- **Data Longevity:** STEP-NC will provide a stable neutral data format that will remain constant and unchanged for long periods of time. This will insure spare parts for long term product life cycles.
• **Complete product and process data definition:** As machining processes are defined, enhanced, collected, and stored based on AP-242, and subsequently AP-238 relative to the machine tool, a robust set of process and machining information will be catalogued in knowledge bases for future use.

• **Interoperability:** The benefits of interoperability are the single most quantifiable component of the adoption of STEP-NC. According to a recent study on interoperability costs by NIST, OEM Machine Builders and tier one End User manufacturers spend about $3.6 billion per year to solve problems associated with imperfect data exchange and interoperability. Moreover, these same OEM Machine Builders spend about $245 million a year just to recreate or correct unusable data. A significant portion of this data exchange is between design and manufacturing systems and across sub-contractor / outsourced manufacturing. STEP-NC will contribute significantly in reducing the cost of interoperability by providing a common open data format of machining processes for the manufacturing community.

• **Post Processing:** An AP-238 compliant NC controller will eliminate “post-processing” as we know it today. One of the fundamental changes from the RS-274D specification to STEP-NC AP-238-based machine feature approach is the exclusion of the need to generate Machine Control Data (MCD) from cutter path data that is unique to the internal motion protocol of a specific machine tool. All of the part generating content including geometry and process information will be embedded in AP-238 data that will flow to the CNC. The major caveat to this, however, is that the CNC and CAD/CAM Technology Suppliers must provide STEP-NC AP-238 compliant systems that can drive the machine tool axis with a generic format. The functionality of the post-processor remains a required element regardless of the format adopted. One of the major benefits for End Users is the elimination of generating and maintaining a large library of post processor data for each machine tool on the shop floor. STEP-NC based programs will not be confined to a specific controller but will produce quality components on suitable equipment combined with a STEP-NC compliant controller.

• **Common Data Formats:** STEP-NC provides a common data format for machine parts from product definition (CAD/AP-203), through product manufacturing information (PMI) (CAM/AP-242), to the ma...
chine tool (AP-238). Additionally, part configuration conformance (AP-214) can also be applied.

- **Harmonization between Standards:** Since STEP-NC is the manufacturing extension of the universally adopted STEP standard, it will be the machine parts and production process standard for manufacturing.

- **Feature Recognition:** STEP-NC through the various application protocols (APs) will provide common feature recognition across a heterogeneous environment of machine tools.

- **Process Feedback Loop:** One of the major benefits of STEP-NC is the capability to make process improvements at the machine tool and capture these changes in the machining process for incorporation into the permanent production process plan. Since there is complete interoperability across the application protocols from AP-238 back to AP-242 and AP-203, actual process improvements can be incorporated at the design level. This will enable the manufacturing process improvements to facilitate design for manufacturing best practices. Essentially, the AP-238 specification will provide the basis for collecting and incorporating process improvement features derived from the machining process.

- **Predictive Trending:** The concept of process feedback from the machine tool provides information for collateral applications such as Machine Condition Monitoring, Asset Management, and Optimal Equipment Effectiveness (OEE) applications. Today, preserving machine tool assets and factory equipment is becoming a major focus for End User manufacturer cost savings. STEP-NC will facilitate establishing best practice strategies for machine tool utilization and maintenance based on the use of common feature set machining practices.

**Resource Skill Improvement**

STEP-NC will provide a common production machine tool environment that enables a common set of machine features, a common look and feel for operators, and a uniform training methodology across a heterogeneous mix of machine tools. Additionally, STEP-NC will promote the use of a common HMI for operators, and much more user-friendly environment.
Outsourced Parts Continuity and Supply Chain Visibility

STEP-NC will greatly improve the business of outsourced machine parts. Job shops and sub-contractors will be able to fabricate parts by eliminating the process of re-defining models and converting tool path data to their internal CAM systems. Common AP-238 defined feature sets generated by the manufacturer will run on any external STEP-NC compliant CAM system or CNC.

Process Variability

Production parts defined in the STEP-NC process steps will allow variability across product and program lines. STEP-NC enables common parts defined and fabricated for a particular program to be used for other programs.

Simulation

STEP-NC will enable more comprehensive tool tryouts and simulations based on the complete set of machining features and process. Moreover, more of these machine parts process can be accomplished offline, insuring that the production operator’s time is used only for machining production parts.

Real Time Simulation

The combination of STEP-NC and more powerful controls will enable real time simulation on the machine with interesting opportunities for new efficiencies and flexibilities through graphical re-entry, real time collision detection, smoother acceleration and tool to surface cutter compensation.

Process Control

STEP-NC creates a machine parts production process environment that permits process variation to be accomplished through the use of Logical Expressions, thus enabling a finer level of tuning the process control.

Cost Savings

The establishment of a feed back loop from the machine tool to machine parts production planning and programming phases will streamline the process of incorporating production improvements, significantly reduce fabrication time, and provide better machine tool resource utilization. Ad-
ditionally, the direct exchange of parts definition and production process information through the common interoperability of the STEP-NC specification will greatly improve the value proposition of outsourced machine parts.

All of this translates to substantial and quantifiable cost savings for the End User manufacturers:

- **Purchasing Power:** STEP-NC compliant components across the Production Lifecycle, from CAD/CAM to CNC and machine tool equipment will provide the manufacturers with enhanced purchasing power for acquiring factory machine tool assets.

- **Single Source Storage:** STEP-NC would enable a central repository for all production process information. This would include NC programs, operator documents, process planning, process sketches, etc. This machine parts process information can be generated, stored, and distributed to support the production process in real-time.
The relationship between an End User manufacturer and its Technology Suppliers is a key determinant of responsiveness. Lean manufacturers are addressing this issue through strategies such as limiting the number of suppliers involved, fostering deeper but balanced supplier partnerships, and extending partnerships to include local support and distribution channels.

At this point, the opportunities for the CAD/CAM and CNC/machine tool suppliers are clearly emerging. The large tier one End User manufacturers have made it very clear that when they find an application or product that meets their design and production requirements, works well with existing systems, and is cost effective, they will invest a significant amount of money on it. Additionally, with the ongoing emphasis on implementing applications, systems, and products that enable lean manufacturing methods, End Users will be looking to those Technology Suppliers who can accommodate their lean initiatives.

![Summary of End User Manufacturer Benefits](image)

The first major CAD/CAM and CNC providers that furnish a STEP-NC compliant product will undoubtedly have a significant edge in this space. Manufacturers will want to standardize on products and applications that provide complete interoperability across their entire product lifecycle, thus leaning their production lifecycles, shortening time to market, while producing significant cost savings across all levels of the enterprise.

Major machine tool, CNC, Robotics, and CAD/CAM Technology Suppliers will need a very compelling business case before they will spend resources to develop and roll out products that are compliant with End User driven standards. Within their own internal organizations, manufacturers need to establish STEP-NC subject matter experts that will be able to apply this technology to their company’s machine parts production processes, and educate those involved in the process. There are specific Technology Supplier sectors that will need to be addressed if the End User community expects to see STEP-NC compliant products in their factories.
Technology Suppliers Need Not Incur Risk by Adopting STEP-NC

It is only natural that the Technology Supplier community will focus on the associated risk involved going forward with a commitment to adopt and integrate STEP-NC into their applications. Development costs and resources expended can add up quickly, which represent significant cost justification issue for large Technology Suppliers and become prohibitive for smaller companies. It should be pointed out that Technology Suppliers who focus solely on the perceived risks associated with STEP-NC are missing out on numerous potential benefits. Those suppliers who are able to make the transition from risk mode to opportunity mode will be the ones most likely to cost justify STEP-NC adoption, take advantage of the relatively short payback period, and derive revenue from the change. Overall, the new market opportunities that STEP-NC compliant products present will mitigate risk of STEP-NC development costs.

Most Technology Suppliers work hard to create product differentiation in order to leverage their technologies, features, and the overall benefits derived from using their products. STEP-NC is a specification that most manufacturers will endorse to promote and enable interoperability and a common machine parts environment. Technology Suppliers should realize that the uniqueness of their products and technologies will not be compromised by a specification that defines a common set of machining features based on the already universally adopted STEP specification for geometry (AP-203). The acceptance of STEP by virtually all CAD/CAM providers has clearly demonstrated that adoption of a standard geometry definition specification has benefited these suppliers rather than pose a risk. This should dispel any fears of losing control of customer installed base based on a common open environment. Additionally, there will be opportunities for new business in areas such as retrofitting of machine tools and CNCs that the installed base need to make AP-238 compliant.
Currently, there is a commonly held perception among the manufacturing End User community, especially the large tier one End User manufacturers, that their primary CAD/CAM providers are not being responsive to their needs. Companies make corporate wide commitments to a single product definition design and manufacturing application, and invest literally hundreds of millions of dollars for an installed infrastructure and a trained engineering staff. Despite this, End User manufacturers often feel that they are being held captive by their Technology Suppliers since there is little chance that they will move to another supplier due to the substantial investment in infrastructure and training. Consequently, the Technology Suppliers have little incentive to respond to customer requests in terms of additional development to accommodate common standards.

Adoption of STEP-NC and AP-238 by the CAD/CAM Technology Suppliers would demonstrate a willingness to meet the End Users’ need for interoperability, and, at the same time, provide opportunities for new business with existing tier one customers as well as with the sub-contractors, job shops, and manufacturing partners in the supply chain.

There are a number of factors that present a significant value proposition that would compel the Technology Supplier community to consider adopting and implementing STEP-NC compliant products. These would include:

<table>
<thead>
<tr>
<th>Participant</th>
<th>Role</th>
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<tbody>
<tr>
<td>Machine Tool OEMs</td>
<td>Provide machine tools that interface with STEP-NC complaint controllers</td>
</tr>
<tr>
<td>Robotics OEMs</td>
<td>Provide robotic work cells that interface with STEP-NC compliant robotic controllers.</td>
</tr>
<tr>
<td>CNC Technology Suppliers</td>
<td>Provide controllers with interpreters for the STEP-NC AP-238 feature set definitions</td>
</tr>
<tr>
<td>CAD/CAM Providers</td>
<td>Offer systems that allow the user to create AP-238 files directly from an integrated CAD/CAM application.</td>
</tr>
<tr>
<td>Third party software suppliers</td>
<td>Provide motion middleware abstraction interfaces for a wide assortment of CNCs and machine tools.</td>
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**STEP-NC Stakeholder Roles**
Lower Development Costs

Both CAD/CAM and NC Controller suppliers would experience lower development cost by adhering to a common standard specification such as STEP-NC. A common interface usually means less development to accommodate disparate data formats and proprietary machine tool protocols.

- **Common Data Sources:** STEP (AP-203) and STEP-NC (AP-242 & 238) will provide common data formats for heterogeneous machine tool environments, ensuring that MCD will be interoperable and moving away from customized extensions of RS-274D based on proprietary protocols.

- **End User Endorsed:** Technology Suppliers can be assured that End Users will endorse STEP-NC compliant systems and equipment and will be the preferred supplier for the purchase of their products.

Portability of Applications

Technology Suppliers that furnish STEP-NC compliant products can be assured portability of applications and equipment, adding value to their products for the End Users.

- **CAD/CAM Environment:** CAD/CAM applications that are AP-238 integrated will provide a direct interface to the machine tool. This will make these applications much more useful to the End User, and provide enhanced product and process improvement feedback loop closure.

- **Version Management:** STEP-NC production process steps can provide version management, which enhances the supplier product.

- **Manufacturing Applications:** Technology Suppliers will be able to include manufacturing process features that will retain portability

Address End User Issues

STEP-NC compliant products will address current End User initiatives

- **Lean Manufacturing:** End Users are re-focusing on methods and practices that will lean out their manufacturing processes and cut costs. Lean Manufacturing methods are being applied once more as manufacturers are focusing on cost savings, efficiency, and operational
excellence. They will respond to Technology Suppliers that offer products and services that facilitate this approach. STEP-NC will contribute by eliminating a significant amount of non-value added process steps to the production lifecycle.

- *Interoperable environment to support DOD and government contracts:* Today most large government program contracts are made up of multiple geographically dispersed End User manufacturers. This necessitates a high degree of collaboration throughout design and manufacturing stages. STEP-NC would provide a common production environment for all contract participants and contribute to collaborative manufacturing.

**Expanded Support Revenue**

Technology Suppliers will be able to acquire additional revenues from support for STEP-NC compliant products.

- **On Site:** Technology Suppliers will be able to provide on-site support as needed.

- **Site Licenses:** Technology Suppliers can expand revenue through more site licenses as users move to a STEP-NC environment.

- **Training:** Additional training for STEP-NC can provide new revenues.

**Design Anywhere, Build Anywhere, Support Anywhere**

True interoperability across design, manufacturing, distribution, and maintenance will enable collaboration across the entire product lifecycle. Just as STEP has provided interoperability in the product definition environment, STEP-NC will provide interoperability for a closed loop manufacturing process for machine parts. These basic concepts are critical to the continued growth of outsourcing in discrete manufacturing where exchange of information and a seamless continuity of the production processes are vital to efficiency, flexibility, shorter product lifecycle, and cost savings. Technology Suppliers that opt to offer STEP-NC compliant products and services will be providing End User manufacturers with the ability to achieve their realized goal of an integrated product lifecycle on a local, regional, and global scale. End Users will select Technology Suppliers that can offer this.
Uniform Data Formats

CAD/CAM suppliers will be able to furnish a common data format that is STEP (AP-203) and STEP-NC (AP-242&238) compliant across all enterprise systems (PDM, SCM, PLM, etc.)

Interoperability

By adopting and integrating STEP-NC the Technology Suppliers will be able to create new opportunities to differentiate their products with the addition of many new features that enhance and leverage STEP-NC

Additional Process Control Capability

The Technology Suppliers will be able to add many new features to their products that provide process control capabilities that will add significant value for the End User. These could include:

- Embedded Adaptive Control
- In-Process Inspection
- Internet-connected applications that provide direct access to the supplier Web site. Potential for new sales channels.
- Integration of additional types of motion control for Robots, CMM, and Automated Assembly.
**Acronym Reference**

For a complete list of industry acronyms, refer to the ARC Advisory Group web page at [www.arcweb.com](http://www.arcweb.com)

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<th>Acronym</th>
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<td>AP</td>
<td>Application Program</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<tr>
<td>CAM</td>
<td>Computer Aided Manufacturing</td>
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<tr>
<td>CNC</td>
<td>Computer Numeric Control</td>
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<tr>
<td>CMM</td>
<td>Coordinate Measuring Machine</td>
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<td>DNC</td>
<td>Direct Numerical Control</td>
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<td>HMI</td>
<td>Human Machine Interface</td>
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<td>MCD</td>
<td>Machine Control Data</td>
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<td>Numerical Control</td>
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<td>Optimal Equipment Effectiveness</td>
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<td>OMAC</td>
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<td>ROI</td>
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