Life Cycle Capable IUID / UID

IUID / UID Material Evaluation Standards to Last a True Life Cycle

IUID / UID for life cycle use poses some challenges: Is the IUID / UID durable enough to go the distance of a full life cycle? When does that life cycle begin? Can the IUID / UID mark meet the demands of life cycle management use? Can IUID / UID be used for recall and traceability of essential components?

This paper makes a case for the implementation of Life Cycle ID at early phases and illustrates the forward benefits.

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Authored by: Laura Jones
Freedom Technologies

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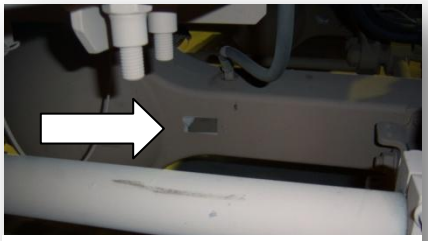
IUID / UID for Life Cycle Management

Life Cycle IUID / UID has to Last a Life Cycle

True life cycle management involves the recording of all pertinent data for a part from the time it enters manufacturing to the last time it is used. This includes the record of its individual raw materials by lot number and source, a record of the manufacturing operations and process with specific information about cycles and actual cycle data for life cycle data mining. Further, it must include record of shipment, location, use, maintenance and repair.

In order to collect all this data and tie it correctly to a subject part, the use of a unique identification is necessary. The current IUID / UID requirement under MIL-STD-130N from the DoD is perfect for this purpose as it is mandated for the life of the parts being identified.

Life cycle management is achieved by constant reading and collection of data from the IUID / UID marks over the life of a part, but *only* if the IUID / UID is present and readable at all stages. Right now, this is not always the case. Our office has reports of missing ID, sometimes to such an extent that it seems it was never present to start with and if the ID is present, it is often unreadable. It is hard to record or retrieve true life cycle data when your chief identifier is missing or illegible.



Field Examples of Failing ID

Material Testing

MIL-STD-130N Requires Durability But Field Failures Do Exist

Durability of IUID / UID material is unquestionably a directive of the IUID / UID MIL-STD-130N, found in the very beginning of the standard under the General Requirements section 4.3 Permanency and Legibility. Quite explicitly, the standard states that the IUID / UID material selected and implemented

"…shall be as permanent as the normal life expectancy of the item and be capable of withstanding the environmental tests and cleaning procedures specified for the item to which it is affixed. "

From an ID material perspective, there are a few key words in this phrase, the most important being *shall*. In all international quality standards, such as ISO or TS, the use of the word *shall* is very specific and has great importance. *Shall* is accepted to mean that the ensuing requirement is not optional. Further, *shall* statements trigger a few other expectations in terms of validation:

- It is normal that compliance with such a statement is, or can be demonstrated by a supplier via test data or a formal quality plan which relies on actual data.
- It is expected that a parts design, quality or certification plan can show positive evidence of compliance with a *shall* requirement.
- The vehicle for this compliance is often a certification, warrant or approval plan.

In reviewing the MIL-STD-130N requirement for permanency and legibility, the authors indicate a well respected and time tested method for evaluation right in the specification itself;

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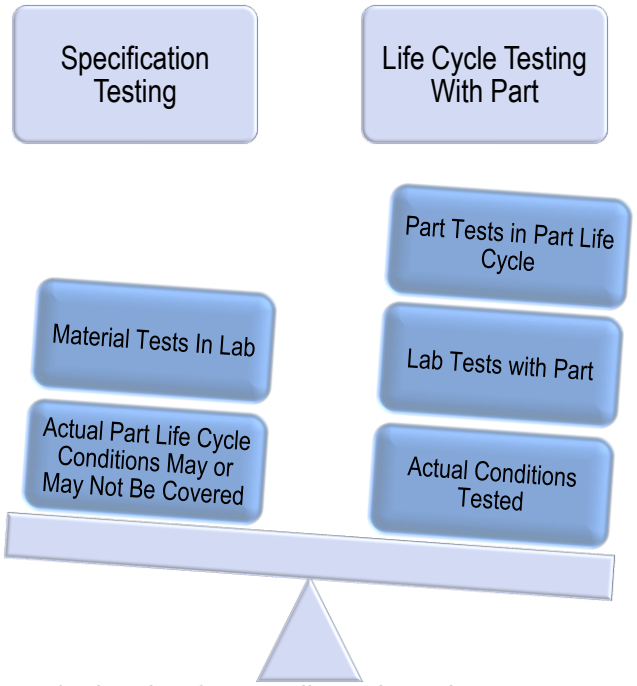
"When IUID / UID is required for new items that are being tested, the marking on the part shall be subjected to the same test conditions."

This is *performance based specification* testing at its very best. Instead of creating an ID material specification which may or may not be suitable for a given part or range of parts, the authors have indicated that the testing methodology and specifications of the governing part are the ones which must be used and met.

It is worth noting that the construction of MIL-STD-130N by describing a performance based testing standard is in line with other industries where identification is considered a design element. The automotive industry worldwide uses such a methodology in testing and validation of ID. They do supplement with specific standards in many cases, but they are drawn from the base standard of the parts for which the ID is intended. In most cases there are no longer large ID material specifications which are intended to cover a global range of critical applications. The automotive industry has long recognized that an ID which is intended to last the life of the vehicle must, therefore, meet the same performance requirements as the subject part.

Part durability testing can also preclude the need for material specifications for multiple types and classes of ID. In other words, by deciding to use the life cycle testing of the part to be ID'd, the need for many materials tests of ID can be eliminated. The actual life cycle conditions for the part the ID is affixed to provide a much higher confidence level for the performance of the ID in normal use. For example the value of testing adhesion to a lab plate in ideal conditions and the force required to peel it at a specific angle vs. testing of a part, ID affixed, in all the conditions which the part must be evaluated. The value of the life cycle testing with the part far outweighs the use of a lab test which may or may not have any relevance to the final application.



This method also creates less of a burden for suppliers since they are not required to purchase "specification approved ID" which often drives costs up. Material testing requires suppliers to spend

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money testing ID to specifications which are different than what they are testing their current parts to. The instrumentation and fixtures necessary for testing ID media are generally not the same type used for testing most military type parts and hardware. The expense of the extra testing equipment or outsourcing of the testing is also saved by performance based testing since current test methods and fixtures are used.

Benefits of Performance Based Specifications

Eliminates the need for multiple individual specifications being written.	Places the burden at the feet of Design responsible party.	Prevents cost increases for IUID material by not limiting competition.	Makes IUID part testing more likely to occur in the design phase of a part - saves costs.

Implementation:

When Should Life Cycle ID be Implemented?

Life Cycle ID[1] is most properly implemented at the very beginning of a manufacturing process, most commonly materials receiving. Implementation of life cycle ID at the beginning of manufacturing allows for a complete life history to be gained and maintained for a given part. In some cases, only critical materials which can affect the overall function or use of a part are tracked at this early stage, but this is a minimum requirement for any good life cycle management system.

Since the premise of this paper is using IUID / UID marks for life cycle management, the next statement is often “I am not putting IUID / UID marks on inbound raw materials”. Absolutely not, nor should a good system require this. It is obvious that some type of scanable ID is necessary for inbound materials and work in process so parts may be tracked throughout the manufacturing process.

However, implementing an IUID / UID mark at this early stage would violate the intent of MIL-STD-130 which desires only full assemblies or finished parts to be marked. Marking all materials would render the IUID / UID useless in the field for its intended purpose due to the number of ID’s per part such a method would incur.

Instead, using a non IUID / UID Work In Process ID (WIP ID) as a scanable unique identifier for the incoming materials allows for achieving full tracking and traceability. This WIP ID should be a scanable ID (code scan or OCR) which will allow for subsequent tracking and traceability of the raw materials through various processes and ultimately into the final products they become. In a well developed system, the incoming ID can be tied to quality documentation on the material received. As the material

[1] Life cycle ID as referenced here is meant to describe the ID or series of ID’s that are used to keep a historic and accurate record of a part. This does not specifically mean an IUID / UID or WIP ID, as it can, and normally will, draw data from both types of ID.

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moves into production and is processed, it will become a wide variety of different parts which will need to be differentiated from each other, but still tied to the raw material lot.

This is accomplished with a good life cycle software system that can go from data generation, to data record recording;

- Track raw material and as the material becomes new parts;
  - Identify each of those parts with a new unique ID.
  - Tie back to the raw material and its pertinent quality information as parts become assemblies via soft records.

As the parts move forward in production, more functional process data can be added to the part life cycle record as it passes to new steps, or the record can be subjugated into a larger assembly. When a trigger point is reached whereby an IUID / UID is required, the current WIP ID's of the parts are all subjugated into the final part record, as it receives the final IUID / UID mark. The IUID / UID mark is tied to it all the individual parts data for raw materials and processing up to that point.

For external clients & users, this IUID / UID becomes the functional life cycle ID that they will use to record all forward information and the one used to inquire of the manufacture when build data is required. If desired, the build data can also be exported under this IUID / UID for a given part to a client life cycle database for use in disciplines such as life cycle maintenance engineering.

Life Cycle Data is Critical

Why early phase implementation of life cycle tracking is important

In many cases the materials being used for manufacture of the final goods are critical to the overall function of the part and the data is extremely pertinent to the overall life cycle of the product. This build data is essential creating a high quality life cycle management system.

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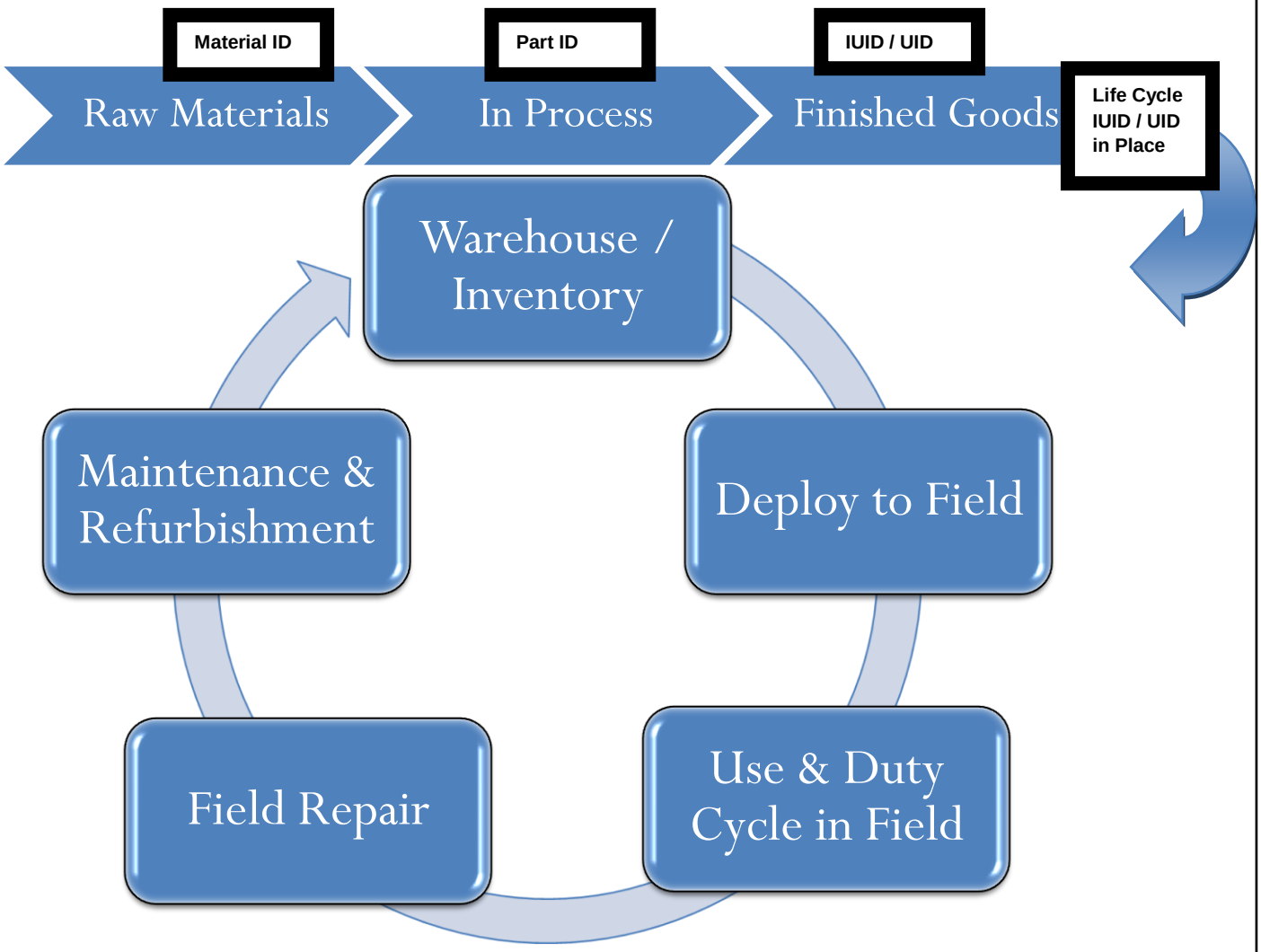
Life Cycle Durability, Start at the Beginning, End at Product Death



Example, The Case of Steel Armor.

Steel armor as a product is an interesting example for several reasons:

- Armor material is visually the same as other steel materials.
- Poor quality can affect life and limb of soldiers.
- Traceability is useful in all phases; manufacturing, field, maintenance, repair and forensic investigations.
- Finished Armor with an IUID / UID can have multiple components from multiple sources.
- Selection of IUID / UID requires consideration of many functional design factors to obtain true life of the part durability.

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The example of armor manufacturing illustrates the critical reasons life cycle management should exist and why traceable WIP ID should be implemented at the beginning of manufacturing.

First Stage; First Unique & Traceable ID

Inbound Receiving & Inspection of raw materials for this product is the first critical phase which should be tightly controlled since incorrect ID of incoming raw material can render the final product useless despite any forward actions.

Armor manufacturing is a function of two critical components; correct raw materials and correct processing. Failure at either of these phases and the final product will not function as required and further, have high potential for causing the loss of human life. (Critical element for both D- & P-FMEA)

The criticality of life cycle management for armor is well illustrated when one considers the raw material itself. Ballistics grade steel is quite different from other steel grades at its inception; its ***Heat Number***[2] refers to the special mixture at pouring which creates the ballistics defense capabilities of the steel. This Heat Number is critical information for life cycle management and should be recorded for all steel armor parts. When the steel arrives as raw material, it suffers from several identification risks which good ID can mitigate:

- **Appearance:**
  - Ballistics steel appears visually the same as other steel.
- **Processing:**
  - Ballistics steel and other steel can be processed similarly without detection.
- **ID Robustness:**
  - ID at this point is often all human readable and requires manual data entry which is prone to error. A significant improvement to steel identification would be to implement scanable ID which would travel with the steel.

By implementing a scanable unique WIP ID (not IUID / UID) the steel type can be confirmed to the inbound paperwork and a validated WIP ID is established clearly demarcating the steel as to its type.

This WIP ID can be scanned for correctness at the first process station where a single sheet can be cut into multiple pieces. This will confirm correct steel type and tie this unique material WIP ID data via software which will record its future life cycle from that point forward. Good life cycle management systems will also tie in the operator, date, time, process function data and exit status of the steel (function data). This becomes a quality control tool in multiple disciplines including the case of forensic investigations of product integrity.

[2] **HEAT NUMBER An identifying number assigned to the product of one melting (e.g.: 721299). *Source; Affiliated Steel & Tubes***

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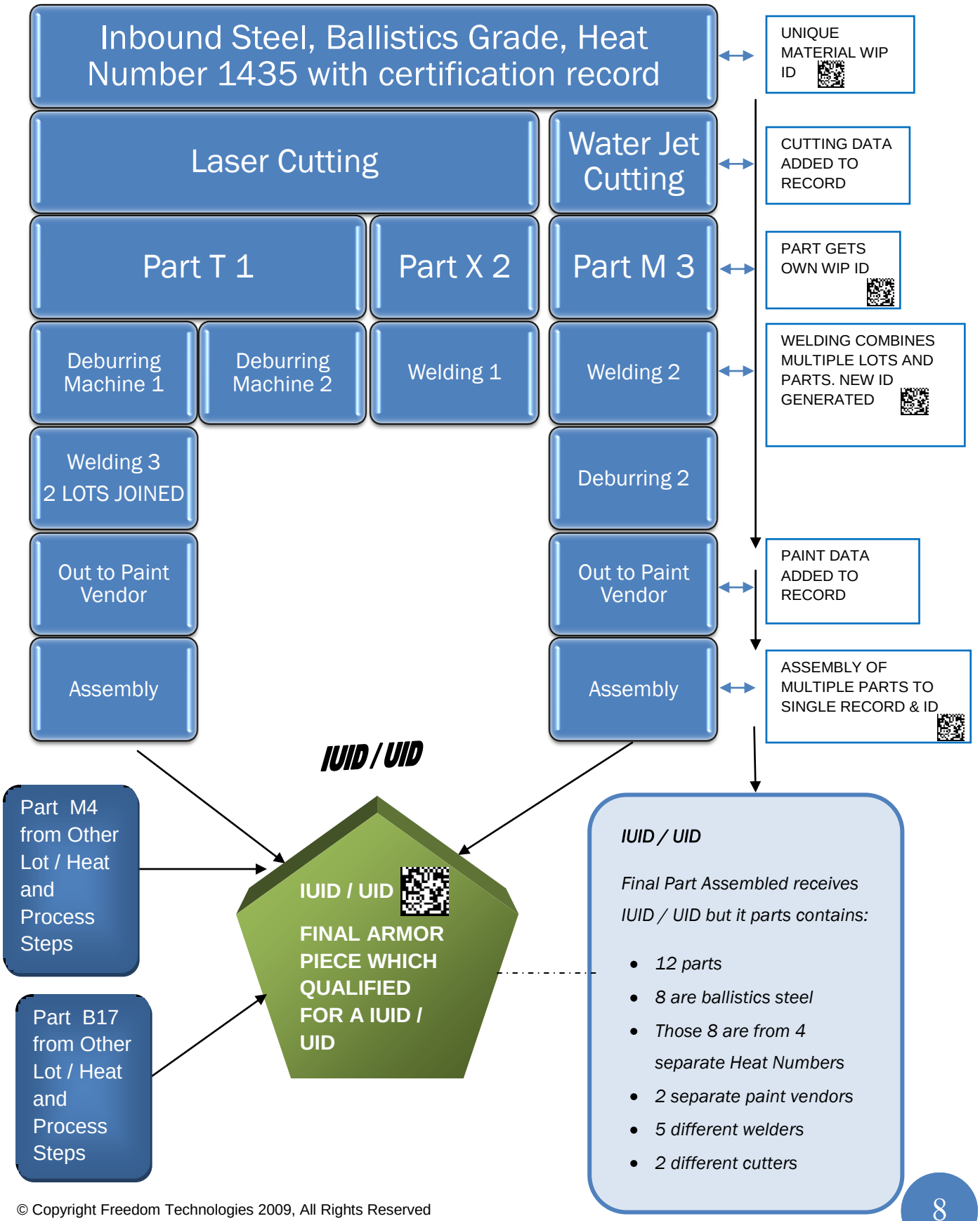
Example Process for One IUID / UID Worthy Piece of Steel Armor



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The ID material selected has to be present and readable until either another ID is assigned and tied to the original data or a parent is established for the component. Design considerations for the ID selected, therefore, must include both current and forward conditions.

ID Material Design Considerations
Example: Armor Steel Manufacturing, Process Review

- WIP ID on raw steel at inbound - needs scannable unique code, must adhere until cutting of steel sheet. Not relevant after cutting, new WIP ID must be established.
- WIP ID each cut piece at cutting station - tied to original inbound WIP ID.
  - Must ID at entry or exit to cutting without mixing lots.
  - Must be machine readable and unique. Must withstand power washing. Must last until painting process. Does not need to be present after painting if new ID is established.
- Paint Finishing WIP ID or IUID / UID. Must adhere to bare metal or toe tag through paint process. Must be unique and readable before and after paint. Heat is 435 F, dwell time of 25 minutes, set back 450 F, and 35 minutes. If permenant, must withstand all forward conditions and not hinder the mission performance.

Keep in mind that this can involve several WIP ID types / materials as parts pass through manufacturing before the final Life Cycle ID or IUID / UID is assigned. The data recorded with each WIP ID must be tied forward when a WIP ID change is made. Design considerations will be a complete compilation of elements the WIP ID has to withstand in production.

It's necessary to consider the elements the final ID (IUID / UID) will need to face once it leaves the plant once the point is established for implementing the actual IUID / UID. These issues should be drawn from the specifications and testing model used for the actual part design. In all cases, it is recommended that the IUID / UID media is designed at the same time that subject parts are designed. This will allow concurrent life cycle ID testing which ensure the survivability of the IUID / UID over the life of the part.

Second Stage; Laser Cutting. Correct WIP ID of the ballistics grade steel at raw materials allows for the steel to be scanned at the first process step after receiving; cutting. In our example, laser cutting of the steel creates many smaller parts from a single uniquely identified sheet of ballistics grade steel.

Each of these smaller pieces must retain the identity of its source material in order that it may be traced back to the original Heat Number. Therefore, each new piece must be given its own unique WIP ID. This WIP ID is linked to the WIP ID of the original sheet of steel via a software record.

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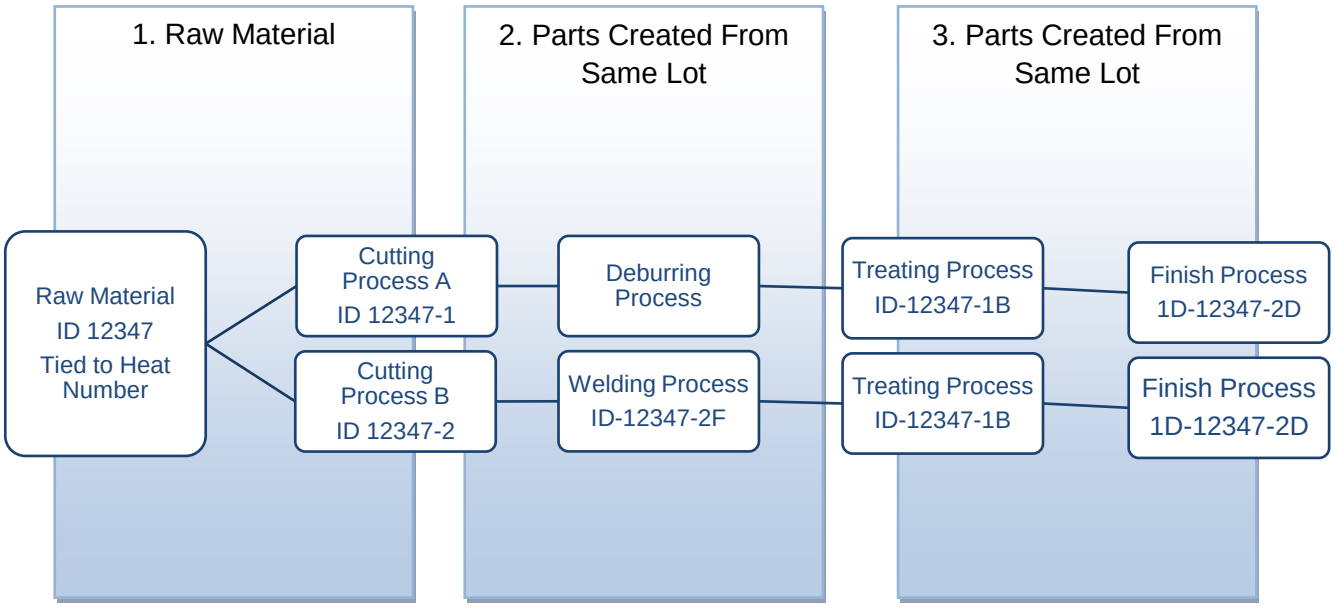
In a best of class system, the MRP or life cycle system will generate a WIP ID for the cut parts and link that number assigned to the original sheet of steel. This linkage is permanent and should be kept in a lifecycle database.



Third Stage; Duburring. The parts will continue through manufacturing and further processes. In our example, the next step is deburring. This operation can occur at any one of multiple stations, each with separate equipment and personnel.

At these same stations, parts which are *not* made from ballistics grade steel are also processed! In order to avoid mixing the types together or substituting grades, the unique part ID type must stay attached to the part and allow for the operation of deburring to occur. Quality data should be collected at these stations by serial number using the scanable unique ID.

Joining Parts & Keeping Data Integrity

Once transferred to welding, the parts will face a new challenge; joining with another part potentially from a different lot and heat and different processes. Joining dissimilar parts from other operations or heats requires that the WIP ID's used be changed or subjugated to a new WIP ID to reflect the new assembly and the joined parts data.

Ideally, each part to be joined is scanned by the operator and married within the software life cycle record. This marriage will allow for the data from both parts to become part of the permanent record of the joined assembly. This assembly then will need a new unique WIP ID (still not an IUID / UID) as it continues in production.

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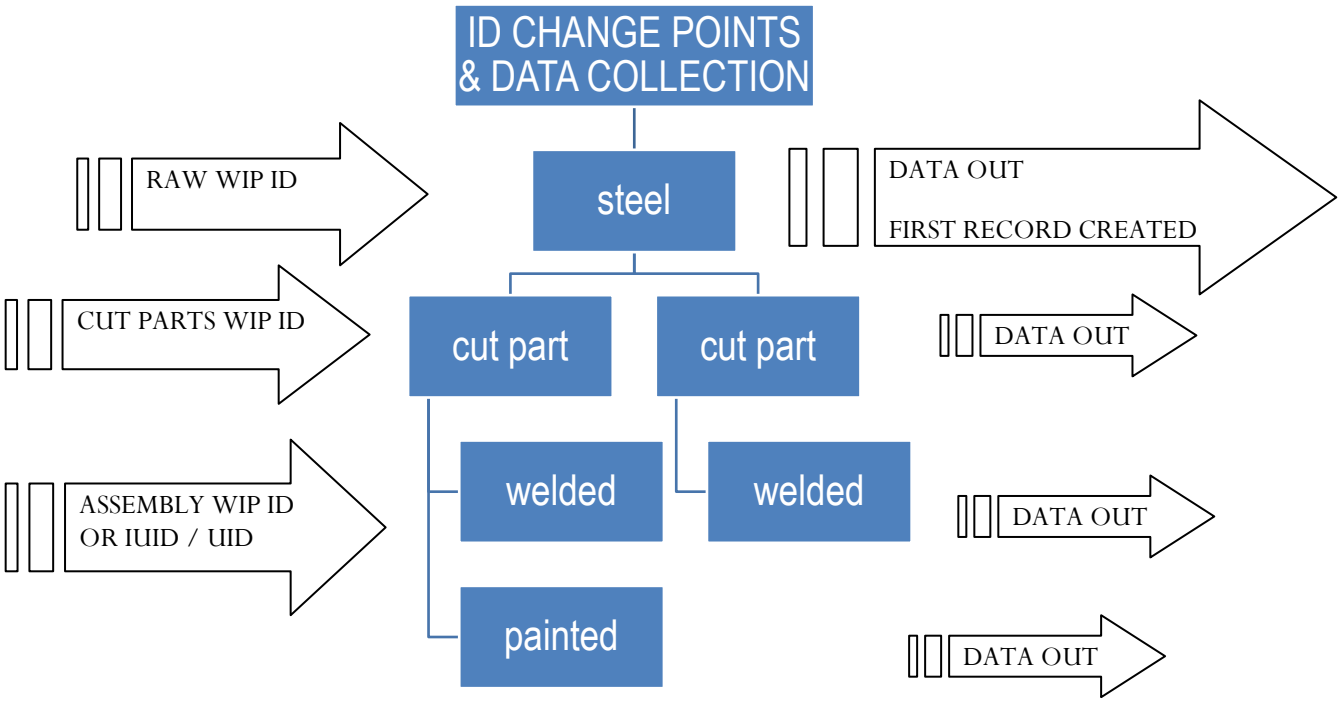
This new ID will be its tracked ID in further manufacturing steps.



Proceeding Forward; Assembly

Proper life cycle management will allow the manufacturer the ability to call up the Heat Number and know – not guess – what final products by IUID / UID contain that heat and even which parts need to be replaced within an assembly.

As the steel is further processed, data is recorded from operations providing a concise history for the armor finally sent to the field. Marriages between parts as they are assembled and finished continue to be made, until finally a part which is designated for its own true IUID /UID is created.

It is at this point, when the IUID / IUD is created, that the IUID / UID string is tied to all the data records of all the parts of the assembly. This provides meaningful life cycle information about the formation and content of the IUID / UID part. This last time in manufacturing, the software will tie together the records of the build and store them under the designated IUID / UID.

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Field personnel can use this IUID / UID for inquiring about life cycle build information or for its standard content of part number, cage code or serial number. By having the life cycle database now established by the manufacturer or the final integrator, the IUID / UID becomes a central point for retrieval of this information. The IUID / UID is well suited for the purposes of tracking life cycle due to several factors:

- Its unique to any given item.
- It is designed to last the life of the part per MIL-STD-130N.
- It is already present and recognized within the DoD.

It is necessary and critical that the component IUID / UID's are designed to remain workable and useable for the full expected life cycle of the final product. The component level IUID / UID is as critical for those circumstances where the component is in question, in need of replacement or repair, or due to become a spare part for example.

The IUID / UID's usefulness as a functional repository of engineering data is as important as its ability to provide traceability and identity. Consider that a part may encounter a new condition and some armor performs better than others – good life cycle management allows for the comparative analysis of process data and material to help determine why some parts are outperforming others.

Factory to Field

Once shipped, the IUID / UID becomes the single access point for all the build data and is the lead for recording all new data going forward. This IUID / UID has full utility for tracking products into warehouse inventories, field deployment, and use and duty cycles.

At time of marking, this IUID / UID has to be correct and ready to make the full life cycle duty for the part. It also must be physically available to those who will need access to it, so location must be considered.

Use and duty cycles are another area where life cycle management data is critical. Field use data can be recorded and tracked for assessment and life cycle predictions by constantly updating the IUID / UID record.

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Why is all this tracking important? Think about the implications of this data if a steel supplier finds out they have a suspect pour and notifies an armor manufacturer of a bad Heat.

Three months after it shipped.

Now what? Recall all production for the last 3 months? Scrap or test every piece of steel in house? What about the soldier in the field counting on that armor to defend their life?

Now think about the same scenario except you know the content of every part in the field and which parts any given Heat Number are in. In this scenario, you are now performing a tracing operation via database.

Usefulness & Utility

Repair & Maintenance

Repair and maintenance on an item can also be recorded and retrieved using the IUID / UID. When performing repair and maintenance, the IUID / UID is critical for determining proper parts by revision levels and correctness. In the case of repair, a functional repair may be made to the part, painting for example. Painting over ID can render the ID unreadable. However, if this is a normal condition and is known at ID design, this circumstance can and should be accounted for in the design of the IUID / UID.

Scanned In, Scanned Out. Repair can also entail replacing parts, which in a robust life cycle management system, should see the old part scanned out of the marriage and the new part scanned in. Again, when a suspect part is in the field, it is critical to know where it is, and this must include replacement parts. By utilizing this scanning of the IUID / UID, it becomes possible to know locations of all parts in the field where an IUID / UID mark has been implemented.

Correct Parts. The ability to determine revision level from an IUID / UID allows for scavenging of parts for further use as they can be tagged and then inventoried clearly in field stores. Proper life cycle IUID / UID will have ensured that this marking has occurred and is still readable. The forward value of these savings are tremendous when cost of spare parts and time to resupply are evaluated.

End of Life Cycle Utility

End of Life for IUID / UID parts occurs under two scenarios; normal end of a duty cycle - no further utility remains, and when a part fails due to outside influences.

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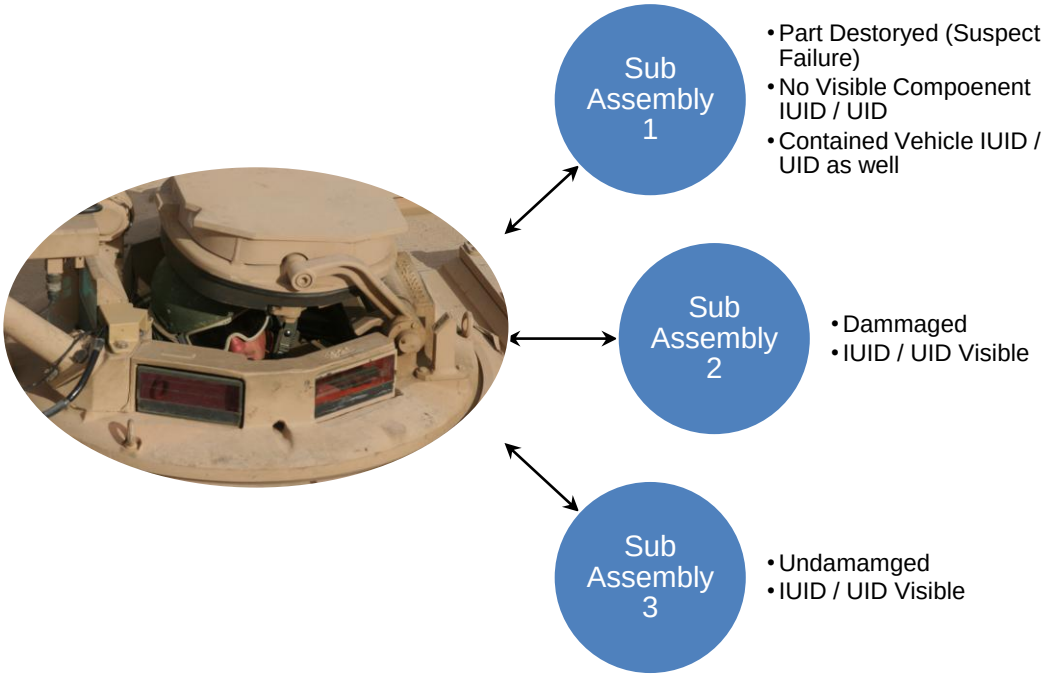
Normal End of Life.

Parts are normally scanned out of the life cycle database when they reach the end of their useful life. This provides a rich and full database for engineering data mining on design issues which can be of great value to manufacturers. Further, this removal of items at end of life will permit an accurate inventory of parts and materiel. In the case where a full assembly is removed, sub components can be scanned back into stores inventory when they are still usable. In all cases, it is necessary to remove "dead" items from the active database or risk devaluing the database integrity.

Forensic Investigations. In the case of failure, the end of life removal has to be made manually, as often the failed part is ruined by external influences like incoming fire or explosives. The IUID / UID is the starting point for forensic investigation when field failures occur. If a piece of armor fails in what should have been a normally survivable condition, the offending parts can be quickly traced back to the manufacturer and to the Heat Number of origin.

In some cases the primary IUID / UID may be destroyed and unreadable. When this is true, the remaining IUID / UID marks on components and the integrity of the life cycle database becomes essential. If an assembly has been built using the track and trace components described here thus far, the ultimate origin, composition and life cycle data for the part of interest can be obtained.

EXAMPLE



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Armor assemblies where components from a variety of sources have been joined are still able to be traced back to the source of manufacture and ultimately to the actual pour records at the steel mill, using a well designed IUID / UID. In the above example, the failed component is part of Sub Assembly 1.

- Sub Assembly 1 has failed and its IUID / UID mark is not readable.
- This assembly contained the master IUID / UID for the entire tank. (If not, then the master IUID / UID for the tank could be used to obtain all the necessary information for the suspect part in the same manner as will be described here below, just without the additional steps).

Start of identification is then begun by obtaining an IUID / UID from another component from the tank. In this case, we will use Sub Assembly 2. The IUID / UID is scanned and the string is obtained. From this number we can determine the following:

- Manufacturer & Cage (contact information).
- Part Number.
- Serial Number (most critical piece of information).

With this information it is possible to go back to the manufacturer and place an inquiry with them. If they have kept a life cycle management and traceability system as described here, the following information will be provided by them:

- Manufacture date of Sub Assembly 2.
- Customer (this is the prime for the tank).
- Date of delivery.

Armed with this information, it is possible to then inquire of the manufacturer, still using this same IUID / UID from Sub Assembly 2. Again assuming a good life cycle management system at the Prime, the manufacturer will be able to look up in its record and determine the following:

- Ultimate tank & IUID / UID which Sub Assembly 2 was placed in.
- A life cycle record for that tank which will list each component and its IUID / UID or WIP ID from its supplier. (Prime contractor having scanned each sub assembly into its life cycle database).
- The affected Sub Assembly 1 is then identified from the bill of materials for the tank, providing;
    - Manufacturer.
    - Part Number.
    - Serial Number.

This is a fully traceable record.

Once the ultimate manufacturer is identified, a detailed inquiry may be made with them as to the components manufacturing data. If required, the Heat Number can be queried all the way back to the steel mill who supplied it.

Vehicles Outfitted at Ports Before Shipment

. Having made inquiries with the largest contractor for this operation, it is clear that they already follow the process of scanning into their database system all parts added to a vehicle by IUID / UID. This database, now used for internal purposes only, contains all vehicle IUID / UID's and all components added to them. Additionally, the company tracks where these vehicles are sent and for whom they are intended.

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Suspect Materials. Failures are not always first noted in the field. Sometimes a failure may be noted at a raw material supplier first. In this case, the tracing of components needs to occur out to the field. This has to be done swiftly and accurately so that potentially flawed products may be removed from use as soon as possible. In essence, this is the same thing we see in our daily lives when automotive safety recalls are issued.

A military safety recall will use much the same methodology but track parts via the IUID / UID, not a VIN. With robust life cycle management systems and a defined procedure and responsibilities, the ability to identify and retrieve suspect components from the field is easily accomplished. When a material is designated as suspect at a manufacturing site, say a bad Heat Number, the life cycle management system records are used to locate all suspect parts.

A query is performed against their database asking for IUID / UID of all components which contain the suspect Heat Number. Once returned, this information will show several important pieces of data:

- What parts or sub assemblies the suspect steel was used in.
- The customer for each of these parts & shipment date.
- What inventory may remain in house from the Heat Number.

With this information, notice may be made to the Prime Contractors who received the parts, referencing the part numbers, serial numbers and IUID / UID data. A similar notice may be sent to the DoD command in case a part has been removed and placed in maintenance stores in the field.

The prime contractor can use this IUID / UID data to query its own database and determine the destination vehicles for the suspect components and notification can be made and a recall completed.

Safety, Performance & Reliability. These are the goals of good product manufacturing and the expectations of all soldiers who rely on armor to protect them.

Living up to these expectations requires full capture and control of information associated with these products by both the DoD and the manufacturers who are dedicated to producing them. One of the essential components for achieving this goal is most certainly proper life cycle management and IUID / UID implementation.

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