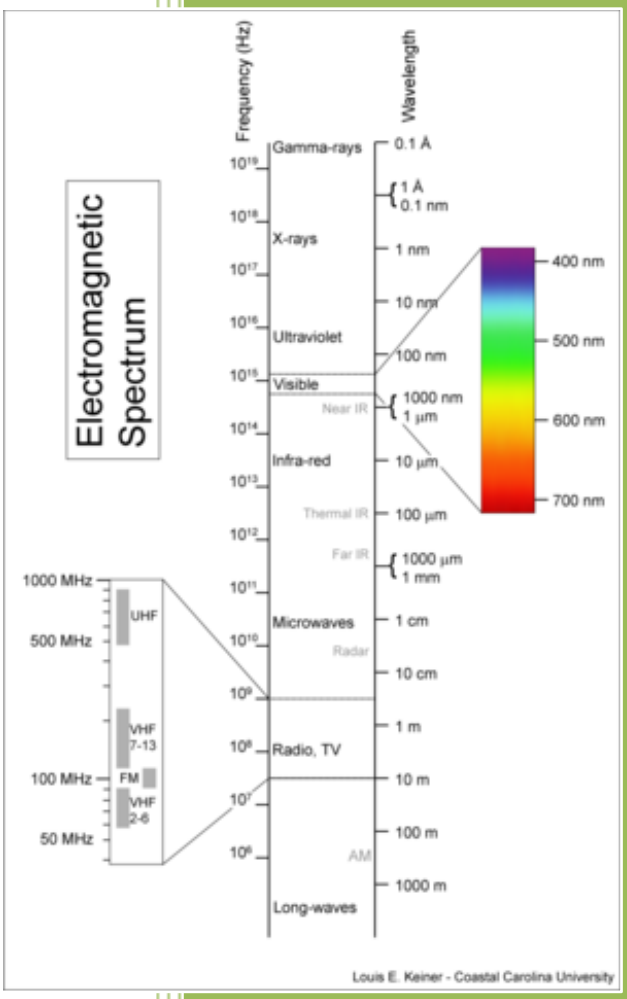
APTUS Identification
ID for a Full Life Cycle

01.2009

LASER TYPE ANALYSIS FOR UID MARKING



Laura A Jones, ID-SME

Freedom Technologies ID Material Science

01.2009

UID MARKING FOR DOD / MILITARY APPLICATIONS USING LASERS

Making A Laser Selection for Best Use Utility & Forward Viability

The mandate for MIL-STD-130 UID marking is driven by the need for accountability of assets, ease of repair and replacement and unified data collection. In order to fulfill this directive, the UID has to be uniform and easy to read. The standard by itself accomplishes most of this, but is silent on marking methods.

This allows responsible parties to investigate and select the best practice for obtaining good readable marks on a wide variety of materials. One approach which is becoming more common is the implementation of a **UID Marking Cart**. This cart concept allows for a mobile work station of marking tools to be moved where needed, thus maximizing resources and the ability to use them in a wide variety of areas.



The primary UID marking we have seen in the military falls into several categories:

1. **DIRECT MARKING OF METALS**
    a. Cast Iron
    b. Stainless Steel
    c. Ballistics Grade Steel
    d. Anodized Aluminum
    e. Cast Aluminum
    f. Polished Aluminum
    g. Painted Metals / Alloy
    h. Galvanized Metals
    i. Chrome
    j. Brass
    k. Titanium
2. **PLATES**
    a. Anodized Aluminum
    b. Stainless Steel
    c. Polished Aluminum
    d. Brass

3. **LABELS**
    a. Etched Labels
        i. tesa® laser labels
        ii. 3M labels
        iii. Aptus ID etched labels
    b. Interior Mark Labels
        i. tesa® 6931
        ii. Field Defense Labels™
        iii. Armor Defense Labels™

In order to select the laser for **the Best Cost Economy & Best Use Utility** it is important to define the terms.

Best Use Utility

Best Use Utility is a financial calculation. The utility is a calculation based on the ability **of the selected laser to accomplish the task at hand**, the **forward tasks which are expected**, and **able to accommodate future technology developments**.

With respect to UID marking, the calculation for best use utility can be made using both industry data and expert data from outside the UID / DoD industry.

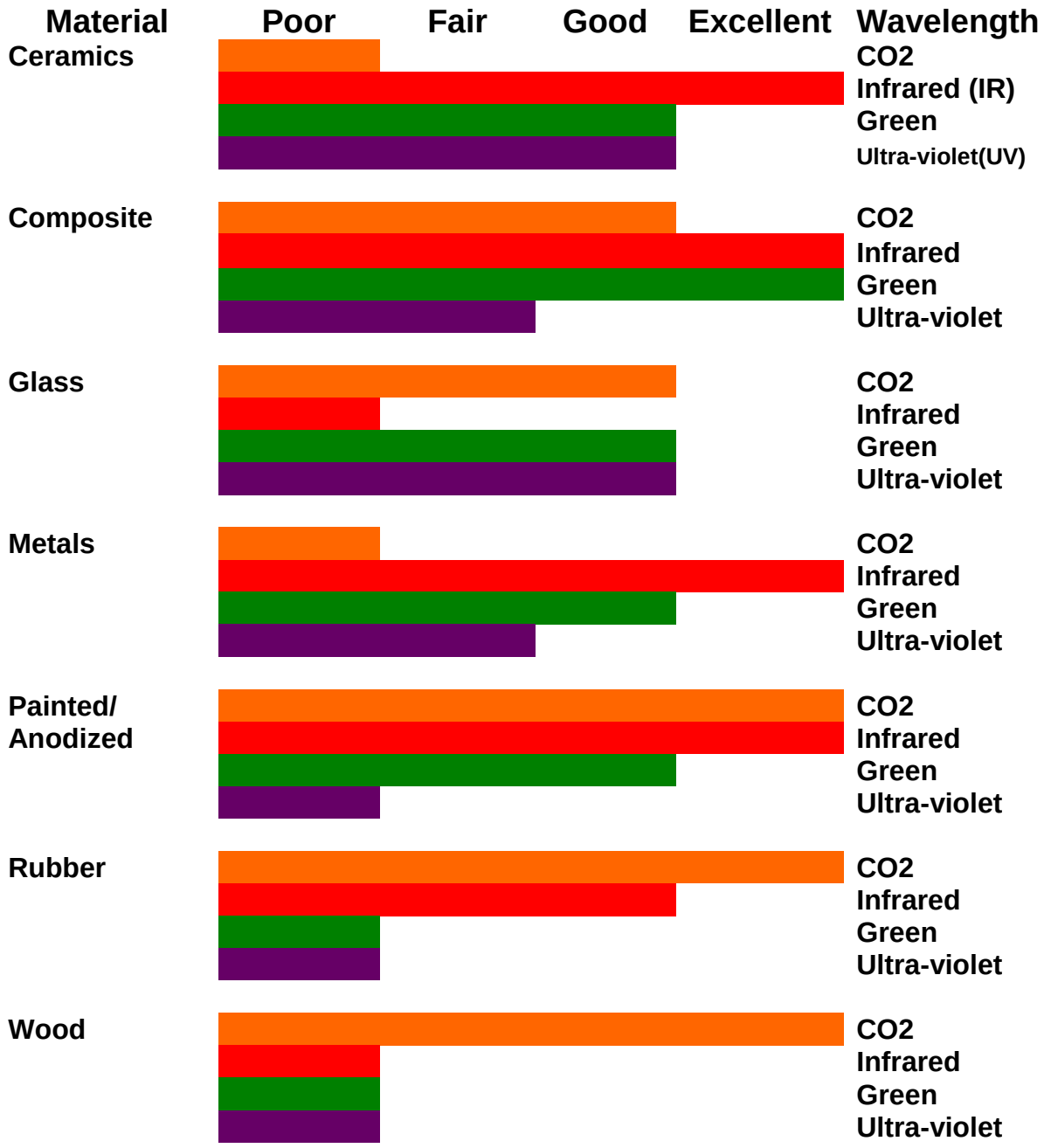
When assessing **Best Use Utility**, we can begin with an assessment of the *four basic types of marking lasers:* **CO2, Infrared/IR, Green and Ultra-Violet**.[1] These four marker lasers encompass the overwhelming majority of all types of lasers used for direct part marking. **THIS GROUPING OF LASERS HAS BEEN ASSESSED BY SOME OF THE WORLDS ACKNOWLEDGED LASER EXPERTS FOR A COMMITTEE REPORT BY THE AUTOMOTIVE INDUSTRY ACTION GROUP (AIAG)ON SUITABILITY FOR DIRECT PART MARKING USE.** [2]

The assessment of these laser sources[3] across common automotive materials which must be marked with a permanent 2D matrix ID is a useful place to begin this assessment. (see chart 1) The chart illustrates the USEFULNESS or Utility of a given laser source type for a given substrate.

[1] Major categories drawn verbatim from the list compiled by the AIAG working committee list of direct part marking lasers.
[2] Major categories drawn verbatim from the list compiled by the AIAG working committee list of direct part marking lasers.
[3] Sources is the laser industry term which denotes the type of laser wavelength being generated and used.

CHART 1

AIAG CHART

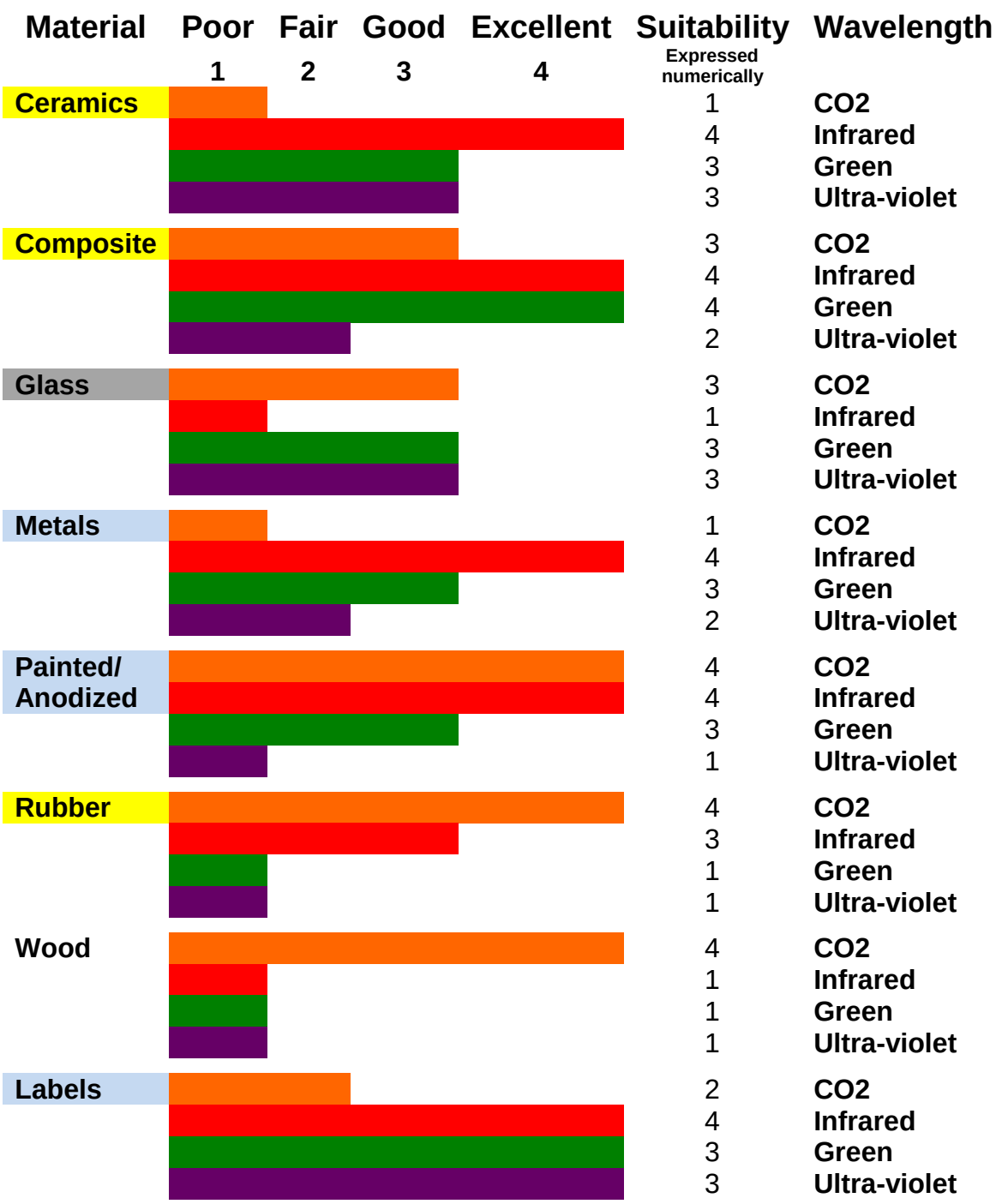


This chart shows a ranking in 4 sections of each laser source for each material. For UID, there are several elements listed under materials which are not germane to the UID community and there is one notable material missing; labels.

First we take the same chart and ranking and add a section for labels in the same format. Then the rankings are given a numerical value corresponding to what is already shown in the AIAG chart. This allows for a numerical / statistical analysis to be made. (see chart 2)

Chart 2 -

Chart With Labels Added & Numerical Values Added



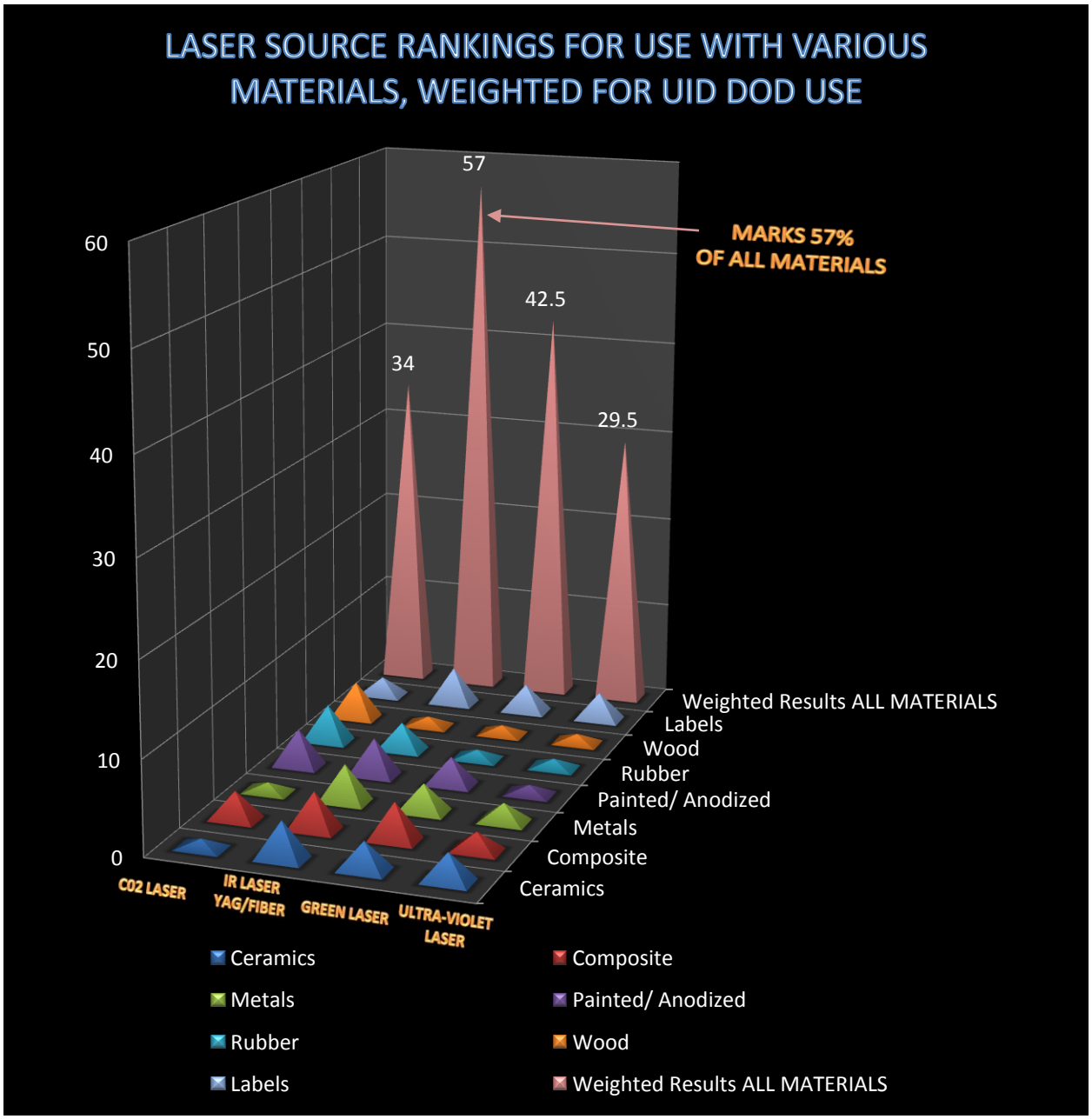
The last modification necessary is the addition of ranking for the materials. The ranking is made for **FREQUENCY OF USE in UID / DoD for marking**. This prevents such items as wood from being weighed equally with steel or aluminum when we know that wood is not marked for UID at all. **Rankings under Frequency : 0 not at all, 1-2 possible but unlikely, 3 is common, 4 denotes very common** (see chart 3)

Chart 3

Frequency of Materials for UID ranking added

Frequency UID USE	Material	Poor 1	Fair 2	Good 3	Excellent 4	Suitability	Wavelength
1	Ceramics					1	CO2
1						4	Infrared
1						3	Green
1						3	Ultra-violet
1	Composite					3	CO2
1						4	Infrared
1						4	Green
1						2	Ultra-violet
0	Glass					3	CO2
0						1	Infrared
0						3	Green
0						3	Ultra-violet
4	Metals					1	CO2
4						4	Infrared
4						3	Green
4						2	Ultra-violet
3.5	Painted/ Anodized					4	CO2
3.5						4	Infrared
3.5						3	Green
3.5						1	Ultra-violet
1	Rubber					4	CO2
1						3	Infrared
1						1	Green
1						1	Ultra-violet
0	Wood					4	CO2
0						1	Infrared
0						1	Green
0						1	Ultra-violet
4	Labels					2	CO2
4						4	Infrared
4						3	Green
4						3	Ultra-violet

By adding these rankings we can now make a statistical evaluation of these lasers and create data for analysis. When presented graphically it clearly shows laser source suitability for each material and then collectively for all materials common to UID. (see graph 1)



GRAPH 1

When viewed in this way, it becomes very clear that

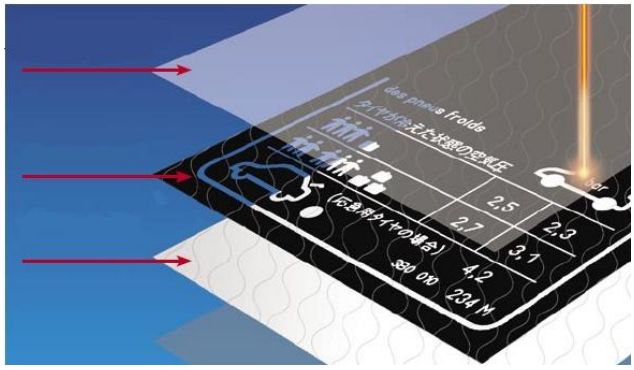
- **IR Lasers has the best Mark Utility** of the lasers considered,

- followed by **Green Lasers,**
- then **Ultra-Violet laser** and
- **C02** coming in 4th**.**

For clarity, it is important to understand how the numbers were derived for the added category of labels. In this case, there was consideration made of all known laser label technologies and their attributes including common use within the UID community now.

The 2 types of laser labels considered were;

1. **ETCHED & ENGRAVED ABLATIVE LABELS**. Tesa® 69XX series of laser labels. (These are the most commonly used labels within the UID community) 3M 7487 laser labels. Aptus ID Etched laser labels. They are all able to be etched and cut with any of the 4 types considered.
    a. These labels are commonly found within the automotive industry as well as the DoD.
    b. They are known as ablative labels as their surfaces are eroded by the laser beam to remove the top layer. This reveals a contrasting color layer below, or "the mark".
    c. By nature, these labels are not highly abrasion resistant or impact resistant. They offer good chemical resistance and have security features.
2. **INTERIOR MARKED TECHNOLOGY LABELS.** Aptus ID Field Defense Labels™. These new labels are marked on the interior of the label, not etched. They are able to be marked with the IR, Green and U-V laser sources.
    a. These labels are commonly found in the automotive industry (example BMW) for engine applications and security labels. They are new to the UID / DoD community but are being launched to address a specified need for improvements over current laser label technology. Test data exists showing:
        i. Improved chemical and fluid resistances
        ii. Strongly improved abrasion resistances
        iii. Strongly improved impact resistances
        iv. Strongly improved adhesive bonding
    b. **Interior Mark Technology is the ability of a laser to create an interior image in a label without breaking or disturbing the top layer.** This critical advance in technology was developed to offer higher durability laser label products for industrial applications.
        i. **It is now being advanced for even further durability specifically for the DoD / Military community**. **A new product due out in February 2009 is already showing exceptional test performance against sand storms.** This has been a weakness of current etched label technology; however the current



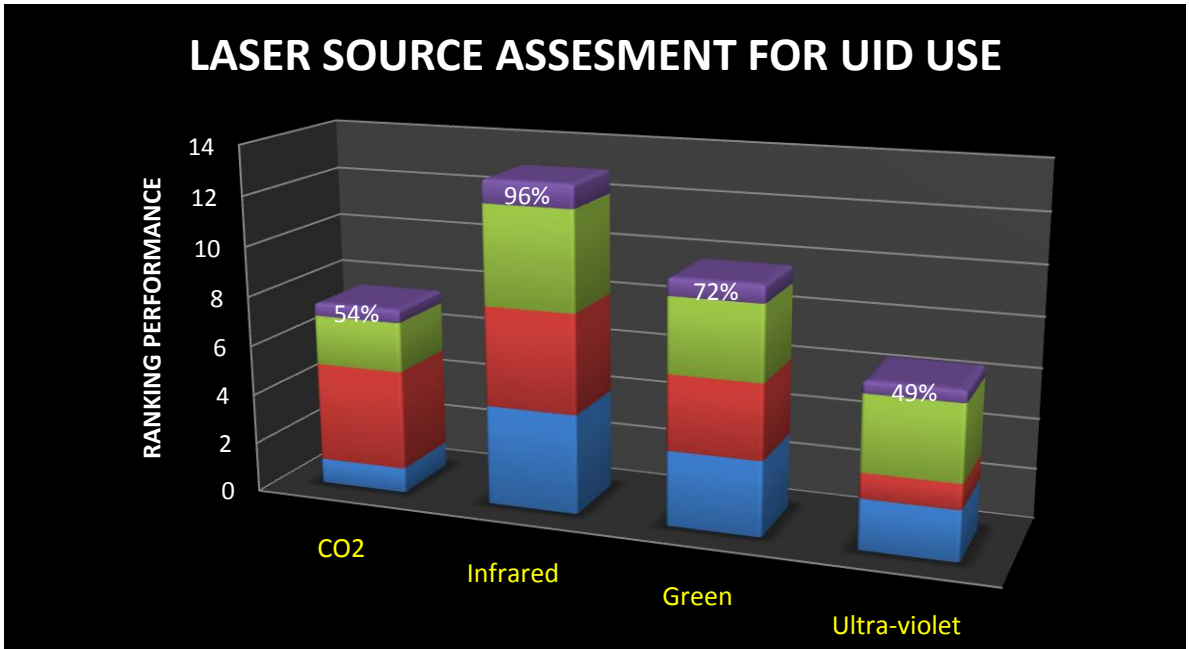
Interior Mark products already perform at a higher durability for sand storm resistance.

The ranking of laser sources were made by their ability to mark all current and known laser label technologies.

We point out the new technologies in order to keep our clients aware of new technology developments which they may be excluded from enjoying by selecting a laser source which cannot work with the new technology advancements.

Best Use Selection Summary

Once the key UID materials are identified, it is possible to rank laser sources by their ability to mark the materials with a passable code and human readable. Strict MIL-STD-130 CODE VERIFICATION CRITERIA were used for this analysis. The primary results are clear as illustrated graphically by Chart 2. The overwhelming ability of the IR, UV and Green lasers to mark a wide variety of commonly used UID materials places them far above the CO2 in use versatility.



	CO2	Infrared	Green	Ultra-violet
Percent Ability to Mark All UID Materials	54%	96%	72%	49%
Labels	2	4	3	3
Painted/ Anodized	4	4	3	1
Metals	1	4	3	2

The results are somewhat surprising when one considers the current strong advocacy and specification of C02 lasers for these applications. Drawbacks are:

- Although they only are able to mark a scant 54% of high volume UID laser marked materials, they account for the majority of laser specifications.
- CO2 lasers are unable to mark a large portion of UID materials at all. (Steel, non anodized aluminum, brass, various other hard metals, any new laser label technology)
- The vast majority of military grade items are made from hardened metals, which are now unmarkable.
- CO2 laser labels are unable to withstand direct sand storm abrasion, several vehicle fluids and cannot be nude on other than flat surfaces.
- CO2 lasers are designed to ablate, engrave or particulate material with which is comes in direct contact. This also limits its use to materials which are, by their nature, receptive to being abraded or eroded. This means the primary material selection for use with CO2 lasers must be a low abrasion resistant product and may be quite unsuitable for battlefield environments where high abrasion is likely to occur.

The superiority of the invisible spectrum lasers, Infrared (YAG, Fiber), Green and Ultra-Violet (UV) over the CO2 has to be weighed against the higher costs of the lasers themselves.

Within the Automotive Industry, which drove 2D part marking mandates through their supply chain several years ago, the high prevalence of laser type for marking is the YAG or Fiber (IR). This selection was made in no small part due to the overwhelming superiority of material marking breadth they hold.

This is not, however, the only logic. Their costs were brought into line with the advent of **new technologies; the diode array and fiber delivery technology for light transmission**.

The diode array replaced the lamp as a light source. This lowered the need for maintenance from monthly (change of lamp), to maintenance annually. (25,000+ hours) The cost of this maintenance was significant. In fact this is now far more efficient than most CO2 charge systems.

The addition of the fiber laser changed the need for external water cooling, reduced the overall package size and allowed for much smaller real estate footprints.

These items combined to reduce IR laser costs for both capital expenditures and ongoing costs of use. When coupled with the more complete ability to mark all UID materials, one sees the clear advantages of these lasers.

Forward Technology

When considering forward technology, it is important to look at the developments of the past several years and which areas are bringing forward new advances. With respect to laser marking, the vast

majority of materials advanced fall into the viable spectrums of IR, Green and UV lasers. In no case has a material for ID been developed which relays on or was designed for a C02 laser.

Some notable advanced in the area of plastics:

- Color change material resins which affect significant color changes when activated at the IR spectrum range (1064 nm) (notably green resins which color change to ultra bright colors such as teal, magenta, yellow and turquoise)
- Resins which are able to be welded via lasers from the IR spectrum range (1064 nm)

Notable advanced in the area of labels:

- Interior Mark technology developed uses only IR, Green and UV wavelengths.
- Paint Mask Technology is also only workable with the IR, Green and UV Wavelengths
- Current R & D is underway to develop an Ultra Durability Laser Labels for the Military to use for a variety of functions, however by nature they cannot work with CO2 lasers

In order to stay open in technology to new market offerings, it is also important to select technology which can grow with the market.