

SELECTING THE "BEST BUY" COATINGS REMOVAL PROCESS

Wayne N. Schmitz
Principal Technical Specialist
McDonnell Douglas Aerospace – East

INTRODUCTION

Time is rapidly running out on the use of toxic methylene chloride paint stripping processes. Fortunately, several viable alternatives are now available, and most importantly, they can be used effectively (and safely?) on both metal and composite substrates. The challenge, therefore, for operators of depainting facilities has shifted from a search for a technology that works to a decision as to which process to buy. Making that decision is no simple matter of buying the lowest price system, however. Confusion and misinformation about the various technologies run rampant. There are many concerns about the actual performance versus advertised claims for the various processes; documentation of realistic operating costs is sketchy at best; and there is still no universal standard by which to certify each technology as safe for unrestricted use on all aircraft types. Confronted with these issues, maintenance operators must, however, make their selection soon. The urgency is driven by environmental compliance coupled with the rapid upward spiral of paint stripping costs.

THE FRONT RUNNERS

There are approximately 12 paint stripping technologies currently offered as environmentally acceptable alternatives to the use of phenol-based, methylene chloride chemicals. Of the 12, 4 appear to be emerging as "leaders." The leading technologies vary widely in their methods of coatings removal. Some use chemical "softeners"; others rely on particulate media blast to erode the paint film; and others use high

intensity light or pulsed-light energy to destroy the surface coating. In order to best illustrate the impact of the best buy considerations discussed in the following paragraphs and how their influence on the acquisition decision varies dramatically with the totally diverse technologies, the processes that appear to be emerging as leaders in the paint stripping market competition will be analyzed:

- Flashlamp/Carbon Dioxide (CO₂) Pellet Blasting
- Laser Paint Stripping
- Soft Chemicals/High Pressure Water Blasting
- Wheat Starch Dry Media Blasting

In the paragraphs that follow the actual performance characteristics of each process described are based on the manufacturers' claims previously demonstrated under controlled conditions.

FLASHLAMP/CO₂ PELLET BLASTING PROCESS

The flashlamp/CO₂ pellet blasting process is actually a hybrid of two established technologies:

- Dry ice (CO₂) pellet blasting
- Pyrolyzation/ablation of surface coatings by impingement of pulsed-light energy from a xenon flashlamp.

In principle, pulsed-light energy bursts ablate the surface coating while a continuous stream of dry ice pellets sweeps away the carbonized residue and maintains the temperature of the

substrate below 200° Fahrenheit (F). The entire process is contained within a shroud, through which a continuous high volume and high velocity vacuum flow is maintained. The vacuum flow transports all the removed paint residue into a series of High Efficiency Particulate Air (HEPA) filters and an activated charcoal scrubber effectively rendering the system discharge non-hazardous.

LASER PAINT STRIPPING

Laser paint stripping, like the flashlamp/CO₂ pellet blasting process, uses high-intensity, pulsed-light energy bursts to ablate the paint film. The laser system also employs an effluent capture system to vacuum away the ablated paint residue. The similarity of the two processes ends at this juncture, however. The pulsed-light energy is generated by a pulsed CO₂ laser. The energy footprint is approximately one square centimeter; the flashlamp footprint measures 1 inch wide by 12 inches long. Whereas the flashlamp is pulsed 4 to 6 times per second, the laser is pulsed up to 1,000 times per second. Pulsing the laser very rapidly and rastering it quickly over the surface yields a strip rate similar to that of the flashlamp/CO₂ pellet blasting process. Because no cooling media is used in the laser process, substrate temperature is controlled by limiting the thickness of paint film removal to one mil per pulse pass. Numerous passes are required to remove normal coating thicknesses.

SOFT CHEMICALS/HIGH PRESSURE WATER BLASTING

Soft chemical technology uses non-methylene chloride-based chemicals (sometimes called "Environmentally Acceptable") to soften surface coatings, which are then blasted away with high pressure (6,000 pounds per square inch [psi]) water jets. The active ingredient in

the chemical softener is usually formic acid or benzal alcohol.

WHEAT STARCH DRY MEDIA BLASTING

Wheat starch blasting is, in many respects, an outgrowth from the Plastic Media Blasting (PMB) process. The primary difference of course is the stripping media. The blasting, recovery, and recycling system is essentially the same for both processes. The primary advantage of switching to wheat starch media is better process control, reduced damage potential, especially on composite substrates, and reduced media consumption. As the wheat starch media is blasted onto the coating surface, it fractures into smaller pieces that are recycled and reused until they are too small to erode the paint film effectively. Unlike plastic bead media, which becomes rounded and less efficient each time the media is recycled, wheat starch particles shatter into smaller pieces each having more sharp cutting edges. The strip rate with wheat starch, therefore, remains fairly constant as compared to that of PMB.

BEST BUY CONSIDERATIONS

The problem that confronts the potential customer, for any of the offered paint stripping technologies, is how to compare the various performance and economic characteristics of each accurately and, subsequently, choose a process that best fits his needs. All too often, emphasis is placed only on strip rate (square feet per minute) or system acquisition cost. While these issues are some of the characteristics against which any system must be measured, they can easily be offset by other critical considerations:

- Pre-strip preparation, e.g., aircraft washing, drying, masking touch labor, and materials costs

- Post strip rinse, mask removal, hand abrasion of masked areas, removal of penetrating media from internal structure, and structural sealant repair
- Requirement for a dedicated stripping facility
- Worker safety
- Worker acceptance
- Media recycling (cost and impact on process performance)
- Media and hazardous waste volume and associated disposal costs
- Repaint adhesion characteristics
- Total aircraft throughput time
- Actual operating cost per square foot
- Certification by aircraft manufacturers and process application approval by government regulatory agencies
- Versatility of the process and compatibility with other maintenance activities
- System reliability (Mean Time Between Failures [MTBF]), maintainability (Mean Time To Repair [MTTR]), supportability costs (spares, consumables, training, manuals, etc.)

Only by weighing all the considerations listed above can the correct acquisition decision; the "Best Buy" be made.

In the following paragraphs each of the four "leading" technologies will be discussed with respect to its characteristics in each of the "Best Buy" categories.

Pre-Strip Preparation – Pre-strip preparation tasks are virtually non-existent for both the flashlamp/CO₂ pellet blasting and laser paint stripping processes. Conversely, soft chemicals/high pressure water blasting and wheat starch dry media blasting

require many hours of aircraft preparation to prevent media intrusion and to provide a clean, dry surface to preclude media contamination. Because flashlamp/CO₂ pellet blasting and laser paint stripping processes use no solid, dry particulate media or chemical compounds to break down the surface coating, the aircraft need not be washed or dried to remove surface soils. Masking surface openings, aerodynamic fillers, and door seals, etc., is also not required since there is no media to penetrate or contaminate the structure. Eliminating these tasks saves approximately one-third of the touch labor costs and the associated masking materials, and reduces the throughput time required to refinish an aircraft.

Post Strip Cleanup – Post strip cleanup tasks and costs vary widely with each paint stripping process. The absence of solid or liquid media, masking materials, or media penetration into the airframe when using either the flashlamp/CO₂ pellet blasting or laser paint stripping technologies virtually eliminates post strip cleanup labor and associated throughput clock hours. Both pulsed-light stripping processes, however, do require a small amount of manual paint removal finish work due to stripping head access restrictions.

Both soft chemicals/high pressure water blasting and wheat starch dry media blasting processes require removal of mask materials and manual removal of paint around door openings, etc. Both technologies also leave the aircraft surface coated with chemical residue or media dust, respectively, which must be thoroughly rinsed away. Each of these processes also tends to destroy form-in-place seals, aerodynamic filters, and butt gap sealants that must subsequently be repaired.

Continuous recycling of wheat starch dry media and its resultant breakdown into fine dust leads to media penetration into the airframe. ..It seems that no matter how carefully the airframe was masked, wheat starch dust still gets inside and must, subsequently, be cleaned out. Wheat starch dust also tends to lodge in seams and joint areas where, if not thoroughly removed, it causes new paint to pop off eventually.

Requirement for a Dedicated Stripping Facility – By definition, this requirement means that whether for personnel safety, media containment or recycling, or stripping environment control, a special facility must be created and used only for a particular paint stripping process.

Because the flashlamp/CO₂ pellet blasting process uses no solid particulate or liquid media; the lamp-focused-energy range is only a few inches; and all the removed coating substances are contained and collected at the stripping source, a dedicated facility is not required. Safety requirements do dictate that personnel working within ten feet of the stripping head wear ultraviolet (UV) rated tinted glasses and ear protection (due to the noise level of the CO₂ pellet blast nozzle). The flashlamp/CO₂ pellet blasting process can be implemented out-of-doors or inside large maintenance hangars in which other aircraft are being serviced. Ambient temperature and relative humidity have no impact on the stripping process.

The laser stripping process employs a very high energy collimated light beam. The hazards associated with the high-energy, pulsed laser beam dictate the need for a dedicated, closed stripping facility. The laser process must be robotically applied and controlled by the

operator safely removed outside the stripping cell. The stripping facility doors must be equipped with interlocks to shut the laser down in the event of unauthorized entry.

Soft chemicals/high pressure water blasting also requires a dedicated paint stripping facility. Soft chemicals do not work well unless the ambient temperature is maintained at 40° Celsius (C) or higher and they are allowed to penetrate for long periods of time (12 to 20 hours) (reference 1993 German Air Force Tornado Study). Add to these requirements a complex recover/recycling system for the removed paint/chemical/water slurry, as well as a robotically applied, high pressure water blast system, and the requirement is a very specialized hangar.

Wheat starch dry media blasting creates a great volume of media and eroded paint dust, which must be contained and from which the operator must be protected, usually by wearing a sealed suit and helmet supplied with breathing air. In addition to containing the media and paint dust, a dedicated facility is required in order to capture, separate the media from paint particulates, recycle the media, and prepare the spent media and removed paint residue for disposal as hazardous waste. Some of the issues described above may be eliminated by a European firm that is developing stripping head (shroud) similar in concept to that used in the flashlamp/CO₂ pellet blasting process.

Worker Safety – The safety of personnel using a paint stripping process is affected not only by the direct interface between workers and the process, but also by the potential hazards posed as the process is applied to the aircraft surface. A consideration

often voiced by potential users of the flashlamp/CO₂ pellet blasting and laser paint stripping processes is the possibility of fire or explosion. The concern is legitimate since both technologies ablate the surface coating by instantaneously raising its temperature to the point at which it explodes off the surface and, in the case of laser stripping, is actually incinerated.

The possibility of fire or explosion with the flashlamp/CO₂ pellet blasting process is precluded by the absence of oxygen within the stripping head shroud. The flow of CO₂ pellets and instant sublimation (into CO₂ gas) on contact with the structure surface is in effect a continuous fire extinguisher. Paint stripping tests over surfaces covered with hydraulic fluid, lubricating oil, flammable solvents, and jet engine fuel have failed to cause ignition of any of these substances.

Laser paint stripping technology does not use a CO₂ pellet flow. It does, however, employ an air knife across the surface to negate the plasma plume formed when air flow is not present. The additional mass of air flow created by the effluent collection system vacuum may sufficiently "lean" the combustible fuel to air ratio to the extent that ignition is prevented. Because laser systems, to date, have been developed only to strip off-aircraft components, such as radomes and helicopter rotor blades, no significant test data is available to assess the fire and explosion hazard. Worker safety for off-aircraft component stripping is assured by keeping all personnel out of the facility during stripping operations.

The flashlamp/CO₂ pellet blasting process is inherently safe as described above. During normal stripping operations, the safety of workers in

proximity (within ten feet) to the stripping head is assured by the use of hearing protection (from high pressure, air blast noise) and by wearing UV-rated, tinted glasses to shield eyes from reflected UV light rays. Because the blast noise level drops off quickly and the reflected flashlamp energy diminishes rapidly outside the focal range, personnel further distant require no safeguards.

Though not as hazardous as methylene chloride, soft chemicals still pose a health risk to workers, especially formic acid. Workers must wear protective clothing when applying soft chemicals. The high pressure (6,000 psi) water blast precludes manual application of the paint and chemical removal part of the process. Robotic application assures worker safety.

Manual application of the wheat starch dry media blasting process demands that workers be protected by wearing a sealed suit and helmet supplied with breathing air. A robotic system application of the process incorporating a capture shroud could eliminate the requirement for protective clothing and breathing air.

Worker Acceptance – Worker acceptance of any technology is tied directly to his comfort level when using it, how difficult it is to apply, and how well it works. In this context the leading technologies are quite different.

Within its present application limitations, laser stripping of off-aircraft components should receive wide acceptance. All operations are robotic, pre-cleaning and post strip cleanup are virtually eliminated, and the operator controls the operation from an environmentally regulated booth.

Depending on the selected application, in this case robotic stripping of off-aircraft components, the flashlamp/CO₂ pellet blasting process will receive the same level of worker acceptance as that of laser paint stripping. On-aircraft stripping operations will be equally well received if the process is controlled from an enclosed booth. Even using a semi-manual application technique, worker acceptance will be assured since safety equipment is minimal, lightweight, and comfortable.

Worker acceptance of soft chemicals/high pressure water blasting and wheat starch dry media blasting processes is likely to be less enthusiastic than that for the pulsed-light technologies. Pre-strip preparation and post strip cleanup tasks are extensive and more cumbersome, less comfortable protective clothing and breathing apparatus is required.

Media Recycling – Both the flashlamp/CO₂ pellet blasting and laser stripping technologies employ no media that is recycled. The costs associated with processing or recycling media are therefore, eliminated.

Soft chemicals/high pressure water blasting and wheat starch dry media blasting processes both require recycling media. Though the soft chemicals cannot be reused, the water used to blast the chemicals and paint off the surface must be purified and used over and over. Wheat starch dry media is recycled until it becomes fine dust and is no longer capable of paint erosion. Recycled water has no impact on performance; however, recycled wheat starch tends to strip at a different rate each time it is reused. Process control is subsequently affected.

Media and Hazardous Waste Volume, and Associated Disposal Costs – With no media to dispose of and hazardous waste limited to the ash-like paint residue trapped in the effluent capture system filters, waste volume and disposal costs are extremely low for both flash lamp/CO₂ pellet blasting and laser paint stripping processes.

Such is not the case for soft chemicals/high pressure water blasting or wheat starch dry media blasting processes. Though not in the same physical state, the stripped paint volume is still large for both processes (in both technologies the paint was removed as a solid). Added to the stripped paint waste, is the spent and contaminated chemical softener used in the first process.

Even though the wheat starch dry media is reused several times, it too must be disposed of when it is no longer effective. The problem is that as the media shatters into smaller particles and finally dust, it can no longer be completely separated from the stripped paint particles and must, therefore, be disposed of as hazardous waste.

With current waste disposal costs ranging up to \$1,000 per 55-gallon drum, hazardous waste disposal costs become a significant element in the total costs to implement either of these technologies.

Repaint Adhesion Characteristics – This is another element of the total paint stripping cost equation in which soft chemicals/high pressure water blasting and wheat starch dry media blasting processes do not fare well. While flashlamp/CO₂ pellet blasting and laser paint stripping processes, employing no particulate media, leave the stripped surface extremely clean (ready for

repaint), the other two blasting technologies leave the stripped surface with either a chemical residue or a coating of dust. Neither condition is acceptable, necessitating extensive post strip rinsing and thorough surface preparation before repainting. Repaint adhesion characteristics are outstanding after coatings removal with the pulsed-light energy systems. Repaint adhesion following soft chemicals/high pressure water blasting and wheat starch dry media blasting processes is average at best. If any trace of chemical softener or wheat starch dust remains in lap joints or surface intersections, the new paint coating will pop off the surface in a short period of time.

Total Aircraft Throughput Time – Aircraft throughput time is determined primarily by pre-strip preparation tasks, the speed with which a process removes surface coatings, and the amount of time spent on post strip cleanup processes. The flashlamp/CO₂ pellet blasting and laser stripping processes virtually eliminate pre-strip preparation tasks; the stripping rate is fast (2 to 4 square feet per minute [sq. ft./min.]); and except for a manual process to strip those areas not accessible with the flashlamp/CO₂ stripping head or laser light beam, post strip cleanup is eliminated. These factors substantially reduce aircraft throughput time.

Again, the other two technologies being analyzed do not fare as well. The impact of the issues discussed in the preceding paragraphs (pre-strip preparation, post strip cleanup, requirement for a dedicated stripping facility, and repaint adhesion characteristics) collectively results in longer aircraft throughput time.

The importance of aircraft throughput time in terms of dollars saved or lost

varies dramatically with every customer's operation. Commercial airlines and express air freight operators place immense importance on aircraft throughput time, whereas it may be less critical to military maintenance depots.

Actual Operating Cost Per Square Foot – Every task and consumable material ultimately becomes part of the total operating cost of any coating removal process; universally expressed as cost (\$) per square foot. The best yardstick against which to assess the relative operating costs of various technologies is a comparison matrix compiled by the United States Air Force (USAF) and United States Navy (USN). This matrix indicates wheat starch paint stripping cost per square foot is five times that of flashlamp/CO₂ pellet blasting, and chemical stripping processes are twice again as costly. Because laser paint stripping experience is very limited, many of the elements of the equation that make up operating cost per square foot are missing. System reliability and economic replacement of parts subject to periodic failure have yet to be demonstrated. And there are no studies similar to those conducted by the USAF and USN comparing the operating costs of lasers with those of other leading technologies. Careful research in this area is a critical prerequisite to choosing a laser paint stripping process. It is important to remember, however, that operating costs for every technology will vary widely depending on geographical location and operating environment; local energy costs; and local regulations controlling the use of and disposal of hazardous materials and toxic waste.

Manufacturers' Certification and Government Approval – Certification and approval to use various paint stripping processes are subjects of major confusion. Until approximately

ten years ago, phenol-based methylene chloride chemical stripping was the only method approved for aircraft depainting. Then PMB was introduced and was subsequently approved by major aircraft manufacturers and the FAA for removing paint from metal aircraft structures. Composite materials were specifically excluded from this approval due to their susceptibility to damage. Recently, as more testing of all technologies has occurred, it became evident that PMB will indeed damage metal structures and restrictions on its use have been levied by several major aircraft manufacturers.

Aircraft structural damage is also a legitimate concern associated with the use of some soft chemicals, especially those containing formic acid, which initiates hydrogen embrittlement in high-strength steel and titanium. Another issue focuses on composite structures; specifically how to prevent damage to epoxy resins by a chemical capable of softening epoxy primer. Finally, internal structural corrosion is a possibility since the chemical/paint film is blasted away with a 6,000 psi water jet.

The Boeing Company has been testing wheat starch blasting on composite structures and has done some preliminary evaluation of the flashlamp/CO₂ pellet blasting process. Airbus Industrie has also initiated testing of the flashlamp/CO₂ pellet blasting process on composite substrates, and Douglas Aircraft Company (DAC) tested and certified the flashlamp/CO₂ pellet blasting process for unrestricted use on all Douglas aircraft in 1993 (reference DAC report number 93K0926, dated 26 February 1993 and All Operator Letter dated 29 July 1993). The Federal Aviation Administration (FAA) subsequently approved the DAC

certification in May 1993 (reference FAA Form 8110-3, dated 93-05-19).

In spite of all these testing efforts and certification, there is still no single, uniform standard by which to certify all paint stripping technologies, though the International Airline Transport Association (IATA) is working hard to develop such a document. A significant problem is that the global engineering community is not of one mind when it comes to understanding the potential effects of such diverse technologies as lasers, ultra-high pressure water (25 to 30 K psi), cryogenic blasting, and hybrids such as the flashlamp/CO₂ pellet blasting process. Any new process must be successfully proven structurally benign to and approved for use by the local regulating authority before any maintenance activity can apply it to aircraft surfaces.

Versatility and Compatibility with Other Maintenance Activities

– One key element that will influence the decision to purchase a given technology is versatility and compatibility with existing maintenance facilities. Almost without exception, major airline operators lack the capital (millions of dollars) for highly specialized, single-application robots or to build new facilities dedicated only to aircraft paint stripping. As discussed previously in the Dedicated Stripping Facilities Section, these requirements are necessary for laser paint stripping, soft chemicals/high pressure water blasting, and at least with respect to a dedicated facility, wheat starch dry media blasting. Regarding versatility, each of the aforementioned technologies has one function; paint stripping. Compatibility encompasses other maintenance activities as well as common facilities. The various issues of safety, process application and control, and dedicated facilities preclude the

performance of other maintenance tasks while these technologies are in work.

Because it is a hybrid of two technologies, the flashlamp/CO₂ pellet blasting process is versatile. The CO₂ pellet blasting portion of the process is a proven hand-held, environmentally friendly, cleaning alternative to solvent degreasers and various particulate blast cleaning processes. This cleaning capability fits well into the work flow of other maintenance activities.

Compatibility means that a flashlamp/CO₂ pellet blasting stripping head manipulator (application device) can be installed on existing maintenance platforms or robots. It also means that paint stripping with the flashlamp/CO₂ pellet blasting process can be accomplished in a large hangar containing other aircraft, and even on the same aircraft on which other maintenance activities are in progress. These capabilities significantly reduce total process implementation costs and add to the value of the technology.

System Reliability, Maintainability, Supportability Costs – System reliability (quantified as MTBF) is, perhaps, singularly one of the most critical considerations on the list. If the various components comprising the technology do not function correctly at least 85 percent of the time the "ON" button is pushed, customer needs will not be satisfied. Certainly, this is one area of customer concern regarding high-tech processes often expressed through the phrase: "New is not necessarily better." A strong suit of the flashlamp/CO₂ pellet blasting process is that both of the baseline technologies are mature. Flashlamp, pulsed-light systems have been operational for 25 plus years. Dry ice (CO₂) pellet blasting technology is about ten years old. All other system

elements are off-the-shelf hardware, which has been around even longer.

Laser paint stripping systems, large enough to depaint entire aircraft, have yet to be developed. Subsequently, there is no test or performance database available to determine reliability performance, maintainability characteristics, or supportability costs.

The soft chemicals/high pressure water blasting and wheat starch dry media blasting processes both employ off-the-shelf hardware, e.g., pumps, compressors, media separators, filters, etc. General reliability of these technologies should not be a major concern.

Nothing lasts forever; however, and when various components do wear out, they must be quickly and easily replaced at minimal costs. These criteria are expressed as system maintainability. One of the key elements of a system's maintainability characteristics is the MTTR, e.g., how long does it take to get the system operational after a failure is identified? Off-the-shelf hardware and modular designs incorporated in the flashlamp/CO₂ pellet blasting system ensure rapid return to service. The same is true for soft chemicals/high pressure water blasting and wheat starch dry media blasting systems. Laser paint stripping systems large enough to strip entire aircraft may be another story, however. Laser systems capable of such performance will be pushing the state-of-the-art and, like most new technologies, will suffer from reliability and maintainability shortfalls.

Supportability costs are comprised of all the "consumables" and scheduled maintenance activities required with any technology. Unexpected failures notwithstanding, the flashlamp/CO₂

pellet blasting process requires a continuous supply of consumable materials, e.g., spare flashlamps, effluent capture system filters, liquid CO₂, de-ionized water, filters, and electrical energy, all of which are available commercially from numerous suppliers worldwide. Scheduled maintenance checks are minimal and add very little to system operating costs.

Supportability costs for large laser paint stripping systems are an unknown quantity. What is certain, however, is electrical energy consumption and costs will be very high, owing to the low efficiency (10 percent to 15 percent) of CO₂ pulse lasers as electrical energy is converted into a high energy light beam.

Supportability costs for soft chemicals/high pressure water blasting and wheat starch dry media blasting processes are substantial primarily due to the large quantities of consumable media used in each process. Many gallons of formic acid or benzal alcohol are used in the former and thousands of pounds of wheat starch blast media are consumed by the latter. Added to these costs are electrical energy, water purification filters, and effluent capture system filters in a closed loop wheat starch blast system.

Each of the elements described above substantially impacts the total system cost of ownership (Life Cycle Cost [LCC]) and must be carefully weighed when making the acquisition decision.

CONCLUSIONS

- Each of the technologies analyzed in this paper is capable of surface coatings removal. There is some question, however, regarding how safely (in terms of damage to the aircraft) each of the technologies can be applied

to easily damaged composite substrates. There are also many concerns and questions as to what parameters must be met to gain aircraft manufacturers' certification and FAA approval for a given process.

- Each technology has some easily recognizable advantages as well as some clearly definable drawbacks. There are, however, some gray areas. One operator may consider a particular characteristic as advantageous to his needs and operating scenario while another may perceive the same technology characteristic in a totally negative light.
- The validity of this conclusion was illustrated time and again in each of the preceding sections. The reality is that no one process is capable of performing every task satisfactorily; all the time; in all applications; to satisfy every potential customer's needs.
- Acquisition cost of any technology is negotiable. Making a technology selection based solely on an advertised market price could be a very costly mistake. The complexity of every potential customer's needs, the wide range of configurations available with most processes, and the very fact that so many technologies are being offered in a highly competitive market all lead to pricing flexibility.
- Life Cycle Cost or cost of ownership really determines the "Best Buy." Up front system purchase price (or leasing terms) is obviously a primary consideration; if you just cannot

afford the technology, all other issues are irrelevant. Assuming, however, your company is in the aircraft maintenance business for the long haul and your primary objective is to show a profit, up front acquisition price rapidly declines as a relevant cost issue. What really stands out on the ledger sheet year after year is:

- What does it cost to use this process?
- Does the technology make me more competitive?
- Can I expand the technology or upgrade its capabilities as the maintenance market changes?
- Will the technology continue to meet tightening environmental regulations with minimal changes or costs?
- Is the system reliable, easy to maintain, or does it hurt my production schedule?
- Is the technology operator friendly or am I continually hiring new people at great expense?
- Can I use this technology for other purposes and thereby increase its worth?

The most accurate way to predict the answers to these questions and, subsequently, reduce the number of technologies on which to conduct a

complete LCC analysis, is to apply the Pareto principle, e.g., determine which significant few issues will have the greatest impact on the LCC of each technology. Without doubt, the greatest single Influence on paint stripping costs and aircraft throughput time is touch labor man-hours. Following touch labor man-hours, is the requirement for a dedicated facility and the implications of that requirement on versatility and compatibility with other maintenance activities. The third major consideration is all the costs incurred when using solid particulate or chemical-based stripping media (media purchase price, recycling, disposal).

A review of the best buy considerations for each of the technologies compared in this paper clearly illustrates the value of this up-front assessment. Based on the most significant issues, the pulsed-light technologies exhibit clear advantages over the media blasting processes. Further comparison of the pulsed-light technologies indicates that flashlamp/CO₂ pellet blasting may be the technology of choice for aircraft paint stripping.

The final acquisition decision, however, should be based on the results of a complete LCC analysis of every viable candidate. The winner of the LCC comparison really is the "Best Buy."