This is sample of the Metallizing studies which have been conducted.

Authors and Title	Purpose of Paper
T. Cunningham, "Quality Control of Thermal Spray Coatings for Effective Long-Term Performance," *SSPC International Conference*, 1995.	This paper discusses the benefits of thermal spray coatings, as well as quality control parameters, surface preparation, and application technique. The author concluded that while TSMCs have relatively high initial applied costs, they can provide economical long-term protection because of their long service life. Ideal coating characteristics include low porosity, a smooth surface, closely controlled DFT, and good adhesion. Quality control measurements should examine surface profile, film thickness, coating adhesion, and porosity.
Fitzsimons, B. "Thermal Spray Metal Coatings for CorrosionProtection." *Corrosion Management*, December 1995/January 1996, pp. 35–41.	This article provides an introduction to the uses of thermal sprayed metal coatings as corrosion protection for steel, as an alternative to paint coatings. **Arc spray, when compared with flame spray, has been shown to give faster output and superior adhesion**. Flame spray may be favorable in areas that are difficult to access. Aluminum and aluminum alloys are used and an alloy with 5% magnesium is currently widely specified, although Fitzsimons is not convinced it provides the best protection offshore. Aluminum-5% magnesium is highly efficient for offshore platforms and ship topsides, where the anodic advantages of the metal are shown. Although experience has shown that sealers are of benefit on exposed aluminum coatings, areas not exposed to driving rain (e.g., undersides of platforms and bridges) may be better left unsealed to reduce the effect of "sweating" or condensation. **TSA (Thermal Sprayed Aluminum) has been shown to be effective against corrosion under insulation**, which might have become wet due to leakage of rainwater through the weather cover. Thermally sprayed aluminum **works well on plant operating at elevated temperatures, coated with epoxy sealers for use up to 120 C and with a silicone aluminum seale**r above that temperature. Fitzsimons also discusses the advantages and disadvantages (cathodic vs. anodic, cost, adhesion, etc.) of different coatings (aluminum, zinc, tin, lead, etc.).
Avery, R. "Application of Thermal Sprayed Coatings in a Shop Environment—Some Practical Considerations." Presented at the SSPC International Conference, 1995, Dallas.	This paper discusses the advantages of thermal spray coatings in comparison with conventional air dry coatings systems. **Some of these advantages include resistance to mechanical damage, provisions for barrier and sacrificial protection, low VOC emissions, and rapid turnaround**. However, the author cautions that quality control, surface preparation, and operator training are necessary to provide superior long-term performance. Compared with air dry coatings, application of TSMCs is more cost competitive with respect to labor, material and schedule costs.
Bailey, J. C. "Corrosion Protection of Welded Steel Structures by Metal Spraying." *Metal Construction*, Vol. 15, No. 5, May 1983, pp. 264–266, 268–270.	**This paper discusses metal spraying of zinc and aluminum on bridges in the U.K.** The authors conclude that zinc is preferable in alkaline conditions while aluminum is preferable in slightly acidic conditions and at high temperatures.
Fischer, K. P., W. H. Thomason, T. Rosbrook, and J. Murali. "Performance of Thermal Sprayed Aluminum Coatings in the Splash Zone and for Riser Service," Paper No. 499. Corrosion 94, NACE, Houston, 1994.	This paper discusses the performance of thermal sprayed aluminum after 8 years of service on offshore TLP risers and tethers. **The authors believe that a 30-year service life is achievable** with a 200 micron TSA coating with the use of specific sealer systems. The authors concluded that a silicone sealer adequately fills the pores of the TSA coating and prevents the formation of blistering. After 8 years of service, the TSA coating on the Hutton TLP production risers and tethers was in good condition. The splash zone area was indistinguishable from the remainder of the inspected components.
Kratochvil, W. R., and E. Sampson. "High Output Arc Spraying—Wire and Equipment Selection." Presented at the SSPC International Conference, Orlando, 1998.	This paper discusses the deposition of two wire diameters (1/8" and 3/16"), three wire materials (Al, Zn/Al, and Zn) and two spray rates (rated at 300A and 450A). **The authors concluded that 3/16" wire, when compared with 1/8", exhibits higher deposition rates and deposits over 60% more material for Al, 32% more for Zn/Al, and 34% more for Zn.** The stiffness of the thicker wire affects operator comfort, range of motion, and fatigue levels.
Rosbrook, T., W. H. Thomason, and J. D. Byrd. "Flame Sprayed Aluminum Coatings Used on Subsea Components." *Materials Performance*, September 1989, pp. 34–38.	The increasing use of arc-spray systems in the overhaul of aircraft engine components has created a demand for new wire approvals. This paper discusses some historical background of the arc-spray process, materials that are presently approved and those that have been submitted for approval. The paper discusses advances in arc-spray systems that make them suitable replacements for plasma spray and HVOF coatings.
Begon, V., J. Baudoin, and O. Dugne. "Optimization of the Characterization of Thermal Spray Coatings." Presented at the International Thermal Spray Conference, Montreal, 2000.	This paper discusses the metallographic process, describing it as the primary way to evaluate thermally sprayed coatings. The management and organization of a metallographic process is of prime importance to keep the process both repeatable and expedient. The paper defines a complete method for metallographic preparation based on a pragmatic approach.
Bhursari, M., and R. Mitchener. "Ski-Lift Maintenance: Wire Arc Spray vs. Galvanizing." Presented at SSPC International Conference, Orlando, 1998.	This paper reviews the use of wire arc spray zinc vs. galvanizing on ski lifts. **The authors discuss a case study in which painted lifts required repainting every 3 years, hot dipped lifts showed signs of corrosion in fewer than 5 years and thermal sprayed ski lifts exhibited no corrosion after 5 years**. It was estimated that the wire arc-spray zinc coating, depending upon the thickness, would have a life expectancy of 20 years with minimal maintenance. The authors concluded that thermal spray coatings were more resistant to abrasion and wear than thin galvanized coatings.

Rogers, F. S. “Benefits and Technology Developed to Arc Spray 3/16 Inch (4.8 mm) Diameter Wires Used for Corrosion Protection of Steel.” Presented at the International Thermal Spray Conference, Montreal, 2000.	This paper **provides an overview of the variables that determine spray rate with the twin wire arc-spray process**. A U.S. patent for spraying wire larger than 3.2 mm (1/8 inch) has resulted in surprising improvements in deposit efficiency and spray rates. The authors also discuss some other design improvements, such as a new innovative nozzle system that atomizes and distributes the spray into a desirable spray pattern, a new patented electrical design mastered arc starting by automatically gapping the wire at the end of each spray cycle, and wire straighteners that prevent kinks and bends.
Greene, N. D., R. P. Long, J. Badinter, and P. R. Kambala. “Corrosion of Steel Piles.” In *Innovative Ideas for Controlling the Decaying Infrastructure* (V. Chaker, ed.), NACE, 1995.	This paper discusses case histories of pile corrosion, as well as theoretical and experimental analyses. The authors concluded that pile corrosion is the result of macrocell activity along the pile surface. Different oxygen concentrations can lead to rapid localized corrosion.
Call, T., and R. A. Sulit. “Protecting the Nation’s Infrastructure with Thermal-Sprayed Coatings.” Presented at AWS International Welding Exposition, Houston, n.d.	This paper summarizes some metallizing applications for the maintenance and repair of the infrastructure and provides a general overview of metallizing technology. The authors provide data on aluminum and zinc spray rates and coverage of arc-spray machines, a comparison of vinyl and zinc metallized coating life cycle cost (LCC) to include maintenance interval, current cost and so forth, and applications. Thermal sprayed aluminum and zinc provide the long-term corrosion control coatings. However, its initial application is usually more expensive than painting or galvanizing if thermal spraying (metallizing) is not integrated into the design and fabrication phases of new construction and repair projects. Aluminum and zinc metallized coatings are tough enough to withstand fabrication, transportation, and assembly operations. The improved capabilities and productivity of metallizing equipment for aluminum and zinc spraying are a major factor in their current cost competitiveness. The net result is that the costs of metallizing, paint, and galvanizing are getting closer every day. **Even though the initial application cost of metallizing may be higher, the life cycle cost (LCC) and average equivalent annual costs are lower than paint coating systems. Metallizing LCCs, when properly engineered into the construction schedule, are equal to or less than paint coating LCCs.**
DuPlissie, K. “Lessons Learned of the I-95 Thermal Spray Project in Connecticut.” Presented at the Fifth World Congress on Coating Systems for Bridges and Steel Structures, St. Louis, 1997	The Research Division of the Connecticut Department of Transportation, sponsored by the FHWA, completed an 8 year project to evaluate the performance of zinc-based coatings for abrasive blast-cleaned structural steel. This study concluded that in order for the coating to adhere to a steel surface, an anchor tooth (jagged) surface profile is necessary. Performance of a bend test is important because 1. It enables adjustment of equipment to proper settings and proper techniques. 2. It allows the inspectors to test the blast and the coating prior to the actual application.
Rogers, F. S., and W. Gajcak. “Cost and Effectiveness of TSC Zinc, Zinc/Aluminum and Aluminum Using High Deposition Low Energy Arc Spray Machines.” Presented at SSPC International Conference, San Diego, 1997.	**This paper discusses the advantages of 3/16” wire feedstock over 1/8”.** These advantages include higher spray rate at lower amperages, better deposit efficiency, higher quality, lower labor costs, lower material cost, lower equipment maintenance cost.
Kogler, R. A., J. P. Ault, and C. L. Farschon. “Environmentally Acceptable Materials for the Corrosion Protection of Steel Bridges.” FHWA-RD-96-058. January, 1997.	**Conclusions pg. 5 of report** **Metallized systems consistently provided the best corrosion protection performance**. All metallized coatings tested showed no corrosion failure in the aggressive, salt-rich environments over the 5 to 6.5 year exposure periods. Steel panels metallized with aluminum and not sealed with a voc-compliant vinyl topcoat began to show minor blushing after 4 years of exposure in the most aggressive environment. The metallized panels that were top coated showed no discoloration over the test periods. Metallizing readily accepts liquid topcoats for cosmetic and color uniformity requirements.
Tsourous, A. “The Restoration of the Historic Trenton Non-Toll Bridge Using Field Applied Thermal Spray Coatings.” Presented at SSPC International Conference, 1998.	This paper discusses the use of thermal spray zinc coating on an existing bridge superstructure. The project specified an SP-10 surface preparation and a minimum DFT of 8 mils. Deposition efficiency was approximately 75%. The material cost was $0.80 per ft2 and direct labor cost was approximately $4.32 per ft2. **The author concluded that while application costs typically exceed those of traditional high-performance coating systems, metallizing’s life cycle cost far outperforms most of these systems.**
Kuroda, S., and M. Takemoto. “Ten Year Interim Report of Thermal Sprayed Zn, Al and Zn-Al Coatings Exposed to Marine Corrosion by Japan Association of Corrosion Control.” Presented at the International Thermal Spray Conference, Montreal, 2000.	The thermal spray committee of the Japan Association of Corrosion Control (JACC) has been conducting a corrosion test of thermal sprayed zinc, aluminum, and zinc-aluminum at a coastal area since 1985. Arc-spray and flame-spray coatings were applied to steel piping at varied thicknesses and subjected to various post-spray treatments. No significant changes were observed in the coating systems after 5 years of exposure. After 7 years, zinc coatings with and without sealing exhibited degradation in the immersion zone. However, the aluminum and zinc-aluminum coatings still exhibited excellent corrosion resistance. The test is scheduled to continue until 2001.

Bland, J. “Corrosion Testing of Flame-Sprayed Coated Steel—19 Year Report.” American Welding Society, Miami, 1974.	This report presents the results of a **19-year study** of the corrosion protection afforded by wire-flame-sprayed aluminum and zinc coatings applied to low carbon steel. The program was initiated in July, 1950 by the Committee on Metallizing (now the Committee on Thermal Spraying) of the American Welding Society. The first panels were exposed in January, 1953. This report presents the results of an inspection of the flame-sprayed coated steel panels made after all panels had been exposed for 19 years. **Aluminum-sprayed coatings 0.003 in. to 0.006 in. (0.08 mm to 0.15 mm) thick, both sealed and unsealed, gave complete base metal protection from corrosion in sea water and also in severe marine and industrial atmospheres**. Where aluminum coatings showed damage such as chips or scrapes, corrosion did not progress, suggesting the occurrence of galvanic protection.
Joseph T. Butler “Is painting Structural Steel More Expensive than Metallizing”	What does it cost the owner to metallized? **The initial cost is slightly higher than the cost to paint. However, the service life of metallized coatings are very long and their life cycle cost (LCC) is significantly lower than the cost to paint and re-paint the same structure**. The example in the paper demonstrates a simple method for evaluating the Life Cycle Cost and the potential for dramatic savings over a 50 Year period.