This chapter discusses the primary environmental costs related to FACO and estimates the expense of addressing them. We estimate the environmental costs for four sites: three Lockheed Martin sites (Fort Worth, Palmdale, and Marietta) along with the Northrop Grumman site in Palmdale.

Environmental issues have a relatively small cost effect on FACO for three reasons. First, even though aircraft manufacturing uses many toxic, highly volatile or flammable materials and processes that can generate environmental concerns, most of these materials and processes are used during parts fabrication rather than FACO, the focus of this report. Second, the four sites under consideration are already involved in aircraft production in one way or another. Thus, many of the environmental issues have already been addressed, with the required permits obtained and remediation equipment installed. FACO operations raise environmental issues only to the extent that current facilities do not address them. For example, if painting can be done in an existing facility, new emissions-control technology might not need to be installed. Furthermore, because aircraft production already goes on at these sites, intangible costs from such things as community activism are less likely.

Three types of FACO activities are significant from an environmental management perspective: aircraft painting, engine runs, and acceptance tests—all of which primarily produce air and/or noise pollution. Air emissions include volatile organic compounds (VOCs) and

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hazardous air pollutants (HAPs) during paint operations; nitrogen oxides (NOx), VOCs, and HAPs during engine test; and noise pollution during engine run and acceptance tests.

Other environmental issues must be resolved. However, they are much less significant for FACO activities than they are for fabrication and subassembly and thus impose a smaller cost burden. These issues include hazardous material handling, storage, and disposal; petroleum, oil, and lubricant handling, storage, and emergency response; explosives storage and emergency response; health and safety, including standard hearing protection and health and safety training; and wastewater treatment. As will be discussed below, however, the costs associated with these nonair environmental issues are not expected to vary significantly across sites.

Costs fall into two categories: tangible and intangible. The former refers to direct costs associated with environmental issues—e.g., installing new air-purification equipment in a paint facility to meet state or national environmental standards. Intangible costs refer to such things as responding to community activism, which can impose a real cost, for example, by delaying production. Within the tangible cost category, there are also two types of costs: recurring and nonrecurring.

We first discuss the sources of regulated emissions as they relate to JSF FACO operations. We then turn to costs, both tangible and intangible.

EMISSIONS SOURCES

Air Emissions

Final paint operations during FACO generate regulated air emissions. VOCs and HAPs, regulated under the Clean Air Act, are emitted from the sealing, painting, depainting, bonding, and finishing processes from material storage, mixing, application, drying, and cleaning. Organic solvents are used as carriers for the paint or sealant and as chemical-coating removers. In the past, aerospace paints and coatings have been solvent-based and thus have contained high concen-
trations of VOCs. According to our conversations with the JSF Program Office and Lockheed Martin, the JSF design has two features that, if successfully utilized, will reduce VOC emissions. First, the use of appliqué coating will reduce the amount of painting required (at the time of this writing, the amount of appliqué that will be used is undetermined, but it is expected that at least some painting will occur). Second, more-extensive use of aqueous-based paints and low-VOC coatings will lead to lower emissions. A preliminary Lockheed Martin estimate of VOC emissions is 0.105 tons per aircraft, based on analogy to the F-16. (If appropriate appliqué or low-VOC paints and improved application procedures are developed before production begins, these emissions could be reduced.) Such HAPs as toluene, xylene, methyl-ethyl-ketone, and methyl-isobutyl-ketone are present as well. According to Lockheed Martin data, HAP emissions per aircraft are likely to be on the order of 50–75 percent of VOC emissions or 0.053–0.079 tons per aircraft. The other source of air emissions is running the engines, which generates NOx, hydrocarbons, particulate matter, and carbon monoxide. The JSF engine, currently in development, is a derivative of the Pratt & Whitney F119 engine, and these emissions rates are not releasable at this time. Therefore, the Lockheed Martin estimates of emissions use the F-15’s

<table>
<thead>
<tr>
<th>Operation</th>
<th>VOCs</th>
<th>NOx</th>
<th>PM</th>
<th>CO</th>
<th>Total Hydrocarbons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint⁴</td>
<td>21.42</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Engine test⁵</td>
<td>0.80</td>
<td>15.11</td>
<td>0.93</td>
<td>4.32</td>
<td>0.81</td>
</tr>
</tbody>
</table>

⁴Assuming a maximum rate of 204 aircraft per year and based on an analogy to the F-16 paint system, 60 gallons of two-part polyurethane coatings.

⁵Assuming a maximum rate of 7 uninstalled and 204 installed engines per year and the F-15 F100-PW-229 engine emissions rates.

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F100-PW-229 engine emissions rates, likely test times, and power settings. Estimates of JSF air emissions by activity appear in Table 7.1.

Noise

Engine and aircraft flight tests make substantial noise, which is regulated through local ordinances and Occupational Safety and Health Administration (OSHA) regulations. Typically, local ordinances covering nuisance noise will restrict flight operations by location, duration, and time of day. OSHA standards cover allowable exposures, the use of personal protective gear, and other noise-mitigation measures.

The JSF engines will not make substantially more noise than other aircraft tested at the three sites. During the CDP, the F119 engine near-field (less than 100 ft) noise levels were comparable to legacy aircraft (F-16, F-18, AV-8B). The far-field (more than 1,000 ft) noise levels were considerably less using JSF flight profiles. These data imply that FACO activities will not significantly affect community acceptance of the JSF program in terms of noise issues.

Other Environmental Issues

Other environmental issues that crop up during FACO are wastewater treatment, hazardous materials handling, hazardous waste treatment and disposal, fuel handling, and explosives storage and handling.

Wastewater treatment will be necessary because, during surface preparation, cleaning, and coating, solvents may be rinsed into wash waters or spilled into floor drains. According to Lockheed Martin, the cleaning of paint booths will generate a nominal amount of wastewater—about 1,000 gallons per month when production is at the maximum rate of 17 aircraft per month—a fraction of the overall wastewater generated at the sites each month, which may total as much as 1 million gallons.

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3The F100-PW-229 engine used on the F-15 is similar in size and thrust to the F119 engine, a derivative of which will be developed for the JSF.
Hazardous materials are normally present in sealants (although Lockheed Martin’s sealants are nonhazardous), adhesives, petroleum products and synthetic lubricants and fuels, cooling and deicing fluid, and batteries. Inorganic coatings containing hazardous materials, such as chromium and cadmium, might also be used. (Lockheed Martin’s current plans for the JSF include the use of chromium-free primers and no chrome or cadmium plating unless there is no other technologically equivalent material available.) In addition, various solid and liquid wastes, including waste solvents, blast media, paint chips, and spent equipment, may be generated throughout painting operations (and spot-depainting to the extent this is performed in FACO). Painting can generate solid wastes from overspray caught by emissions-control devices—e.g., paint booth filtration systems, depainting if necessary during rework (spent blast media, chips, and paint sludge), paint equipment and bay cleanup operations, and paint disposal. Used petroleum and synthetic solids and fluids are hazardous wastes and must be treated and disposed according to Resource Conservation and Recovery Act standards. Lockheed Martin states that it recycles these materials wherever possible to minimize the hazardous waste stream. Again, however, most of these materials are likely to be used during fabrication; Lockheed Martin estimates, by URF cost, that 2 percent of all hazardous materials used during manufacture will be used during FACO.4

FACO operations also involve safety issues related to explosives handling and storage capability for those explosives used in the ejection seat. Aircraft operations will necessitate fuel storage and spill-response capability. Most of these issues are covered under DoD regulations and safety standards and require facilities and equipment. Lockheed Martin has stated that it anticipates no significant changes will be required to address JSF FACO compared with legacy FACO operations.

In sum, all of these issues are expected to involve relatively minimal expense and management time during FACO. Most of the hazardous material handling and surface preparation or priming will occur during fabrication and minor assembly. Therefore, while the estimated

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FACO portion of these costs is included in our analysis, a detailed analysis of the costs and potential variability across sites (also anticipated to be minimal) was not performed.

ENVIRONMENTAL COMPLIANCE COSTING APPROACH

Background

Environmental, health, and safety costs include all the recurring and nonrecurring activities associated with planning, permitting, and National Environmental Policy Act (NEPA) analysis; community reporting; employee training; hazardous material handling; wastewater treatment; disposal fees; operations safety; employee health monitoring; fire hazards; and pollution prevention that may occur during the life-cycle phase of interest (in this case, FACO).

The 1995 Defense Authorization Act, Section 815, requires environmental cost analysis to be included in the overall life-cycle cost analysis of all major defense acquisition programs. Acquisition Regulation DoD 5000.2R requires these costs be included in life-cycle estimates and also requires a programmatic environmental, safety, and health evaluation (PESHE). The PESHE describes the program managers’ strategy for meeting environmental health and safety requirements, establishes responsibilities, and identifies how progress will be tracked. DoD’s Cost Analysis Improvement Group (CAIG) guidance for program office estimates is that they must contain environmental costs including pollution prevention, compliance, remediation, restoration, conservation, litigation, liability, added management or overhead, operations and maintenance, and demilitarization and disposal. However, environmental costs do not need to be separated unless they are a significant cost or risk to life-cycle costs.

According to the Air Force Materiel Command’s *Environmental, Safety, and Health Cost Analysis Guide*, the environmental-associated costs during acquisition are a minimal part of the total life-cycle environmental cost (EER Systems, 1998). From a total life-cycle cost point of view, the operations phase has much more significant implications (in large part because of its duration) for DoD than manufacturing activities. This is not to belittle the importance of planning and assessing environmental issues during acquisition. Careful
planning and analysis is necessary for smooth and timely operations and to ensure that no costly delays occur. In a 1995 DSMC survey of 118 weapon system programs, 70 percent of the programs responded that environmental issues had an impact on their program, and 63 percent stated that their programs were affected in two or more ways. Most of the effects were detrimental: Reports cited increased cost (76 mentions), followed by schedule delays (38), degraded system performance (10), and inability to meet system requirements (6) as the most common (Noble, 1995, Table 12-3, unnumbered pages).

Despite these effects, detailed information on the environmental portion of weapon systems costs is not generally available. Particularly during acquisition, these costs are most often included in overhead and are not easily disentangled. Moreover, historically these costs have not been identified on the cost analysis requirements document. One Aerospace Industries Association estimate suggests that between 8 percent and 30 percent of a weapon systems' overall life-cycle cost (which encompasses much more than production) stems from environmental, health, and safety issues. Lockheed Martin estimates that environmental costs associated with JSF FACO are a small fraction of overall acquisition costs.

Environment Cost Estimating Overview

We have tailored our analysis to focus on the major environmental issue during FACO, which is air emissions. There are differences across the potential FACO sites. The Fort Worth and Marietta sites are in “serious” nonattainment areas for ozone. Thus, similar control technologies and other measures to reduce VOC emissions (contributors to ground-level ozone) will be required at both sites. Palmdale is in a “severe” nonattainment area for ozone. Thus, this site will have stricter standards placed on VOC emissions and other measures. Fort Worth and Marietta are in attainment for the other criteria pollutants; Palmdale is out of compliance with California

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5AIA, 1997. For some weapon system types, such as chemical weapons, the demilitarization and disposal expenses of the life cycle can be quite large.

6“Nonattainment” areas are those regions that do not meet the primary standard for criteria pollutants established by the EPA. There are five classifications of nonattainment for ground-level ozone: marginal, moderate, serious, severe, and extreme.
standards for particulate matter. (See Appendix D for discussions on environmental regulations and air-quality standards.)

Other possible causes for cost variation, such as community activism and enforcement activities, may influence cost directly or indirectly through schedule risk and operations flexibility. These are discussed in detail later in this chapter.\(^7\)

Aggregate-level analyses of plant-siting decisions, as well as interviews with national associations and several large corporations, suggest that environmental regulatory stringency is a minor factor in plant location decisions.\(^8\)

No quantitative information is available on state-to-state differences in compliance costs, regulatory stringency, or complete permitting times and expenses.\(^9\) The indexes commonly used, such as League of Conservation Voters State Scorecard and the Free Index, do not focus on cost differences and mostly represent a subjective judgment of political climate, environmental quality indicators, and regulatory standards.\(^10\)

\(^7\)The trend in the private sector and in DoD is to treat environmental, safety, and occupational health issues together. While the compliance costs for health and safety issues are included in our cost estimates, their likely effect on FACO location decisions did not warrant detailed analysis.

\(^8\)Oates, 1998; Gray, 1997. We also gathered data from personal contacts with several large corporations, 2001; Ellen Davis of the National Association of Manufacturers, 2001; and Chuck MacCary of DEALTEK, 2001. Interviews with personnel in state government and in DoD support this conclusion as well.

\(^9\)Permitting fees and statutory time lines are provided by some states. However, there is no information on the true costs (those that include administrative expenses borne by the company) and preparatory times. For some years, the Department of Commerce conducted an annual survey of pollution abatement and control expenditures (PACE data). This survey was suspended in 1994. One analysis of data, which controlled for state industrial composition, gave counterintuitive results (Levinson, 1999). A subsequent conversation with Dr. Levinson indicated these indexes were too aggregate a measure to use for our analysis. We also were concerned that the full effects of the Clean Air Act Amendments (CAAA) were not represented in the data.

\(^10\)Several indexes have been cited in the literature. These include: Conservation Fund Index, which evaluates information on land-use characteristics, environmental characteristics, League of Conservation Voters’ assessment of congressional delegation voting records, existence of state Environmental Impact Statement processes, and statutory language related to land use; Free Index, which is a onetime index (1991) of 256 measures of public policy and environmental quality; and the League of Conservation Voters, which performs annual scoring of environmental interest in
Our research also suggests that less variability in environmental stringency can be found across states compared with that of the 1980s, particularly because federal laws have leveled the playing field. However, there are differences in the type of control technology required in different areas. There is also some evidence that nonattainment areas have less growth in polluting industries, and that states with tougher standards (as determined by political climate and regulatory stringency measures, not directly by cost) have fewer new plants. In addition, interviewees expressed opinions regarding the difficulties in working with various states based on anecdotal information. Finally, the historical trend in environmental regulation has been toward more-stringent control. While we expect this trend to continue, it is not possible to predict its effect on required pollution-control technology and associated costs.

Our analysis relies heavily on information provided by Lockheed Martin and Northrop Grumman, validated when possible by independent sources. As mentioned earlier, environmental costs for acquisition are typically included in overhead accounts. Therefore, disentangling these costs, particularly for a subset of production, is difficult. Furthermore, there is a dearth of independent information readily available, and collecting such data, if possible, would be time-intensive and well beyond the scope of this study.

The costs associated with each alternative location were determined by calculating the nonrecurring investment required to meet environmental standards for anticipated FACO operations at the site combined with the recurring estimated environmental costs arising from FACO operations. Because air emissions during painting, coating, rework, and engine run are the most significant environmental emissions during FACO, these costs are identified separately. Because the final sites selected for detailed analyses are existing aircraft-manufacturing facilities, uncertainty regarding community

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12 Gray, 1997.
13 Based on our review of the literature and available briefings, contacts with major corporations, and interviews with staff members in PA&E/CAIG, OUSD/ES, JSF Program Office, NAVAIR, ANG/CEV.
relations (about noise, traffic, etc.) and potential schedule delays as a result of permitting are less than they would be if the facilities were built from scratch (in greenfields, for example). Assuming the facilities remain in good standing—and all indications are that they will—each will likely have most of the necessary management systems, basic permits, and equipment in place, mitigating cost variability and uncertainty.

**COMPLIANCE COSTS FOR AIR EMISSIONS**

The facilities and equipment requirements to control air emissions are presented in Table 7.2. Table 7.3 contains estimates of the costs of the environmental technologies. Table 7.4 summarizes the air emissions and control costs at each of the four sites. Information on the special air environmental control technology and equipment is treated here; facility investment requirements are addressed in Chapter Three.

As each of the tables indicates, while standard environmental costs are associated with each facility, FACO activities will trigger regulations or costs unique to the location of the facility, based on state and local environmental regulations. Because each of the three states uses the Clean Air Act as the basis, or “floor,” for its air emissions regulations, certain regulatory similarities exist in terms of threshold values that each facility must comply with. However, permitting flexibility, emissions banking systems, additional emissions standards based on severity of nonattainment areas, and state-assessed fees all could contribute to increasing or limiting costs associated with environmental regulations during the FACO process.

The estimated emissions from the FACO process are the same across the sites. Adding up across the different sources in Table 7.2, assembling and checking out 204 aircraft a year is expected to result in 25.1 tons of VOC emissions, 15 tons of NOx emissions, and 0.9 tons of particulate-matter emissions. These estimates are based on past FACO experiences. If greater use of water-based paints occurs or if appliqué is used extensively, then VOC emissions could be lower.

Below, we discuss the findings on environmental compliance costs for each site.
<table>
<thead>
<tr>
<th>Facility</th>
<th>Estimated Annual FACO Operations Emissions by Pollutant&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Environmental Control Equipment Required</th>
<th>Equipment Investment Cost</th>
<th>Equipment Annual Operations and Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint facility&lt;sup&gt;b&lt;/sup&gt; VOCs = 21 tons</td>
<td>All sites: three-stage Aerospace NESHAP-compliant paint filters</td>
<td>Three-stage filters: $1,000 per paint booth&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Three-stage filters: $333 filter replacement per paint booth&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All sites: NESHAP-compliant high-velocity, low-pressure spray guns</td>
<td>$400 per gun (robotic paint facilities have two guns per paint booth; normal paint booths one gun)</td>
<td>$500 per gun</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lockheed Martin–Palmdale: AVAPCD BACT will require 96%+ control device for 650,000 cubic ft per minute if new construction or extensive modification required</td>
<td>96%+ device: $20,000,000&lt;sup&gt;e&lt;/sup&gt;</td>
<td>96%+ device: $2,000,000&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Northrop Grumman–Palmdale: convert existing depaint facility to a paint facility and install new depaint equipment in another building</td>
<td>$10,000,000</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>Appliqué area&lt;sup&gt;c&lt;/sup&gt; VOCs = 0.016 tons per aircraft = 3.300 tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Estimated annual emissions are based on facility activity.
<sup>b</sup> Includes two paint booths.
<sup>c</sup> Includes two paint booths.
<sup>d</sup> Estimates based on three stages of filters.
<sup>e</sup> Cost estimates may vary depending on specific requirements.
### Table 7.2—continued

<table>
<thead>
<tr>
<th>Facility</th>
<th>Estimated Annual FACO Operations Emissions by Pollutant</th>
<th>Environmental Control Equipment Required</th>
<th>Equipment Investment Cost</th>
<th>Equipment Annual Operations and Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hush house</td>
<td>NOx = 15 tons, PM = 0.9 tons, VOCs = 0.8 tons, CO = 4.32 tons, HAPs unknown</td>
<td>All sites: No BACT requirement for jet engines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel barn/facility</td>
<td>VOCs = 0, HAPs = 0 (Enclosed fueling systems)</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explosives Storage</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel handling and spill response equipment</td>
<td>N/A</td>
<td>N/A</td>
<td>Rolled into general overhead costs</td>
<td></td>
</tr>
</tbody>
</table>

*Assuming 204 aircraft per year.

*Emissions estimate assumes no appliqué and similar paint systems to the F-16. If new application technologies were used, VOC emissions would be lower.

*Based on experience with the F-16. If aqueous-based paints, low-VOC coatings, and appliqué are used extensively, VOC emissions could be lower.

*Six booths required for maximum rate of 17 aircraft per month. A reduction in the number of paint booths could occur with a production rate between 11 and 13 aircraft per month. Lockheed Martin was unsure of the exact breakpoint that would reduce the number of paint booths required.

*This incinerator is scaled on production rate. The given cost assumes a facility with six paint booths.
## Table 7.3

### Environmental Analyses and Permitting Costs

<table>
<thead>
<tr>
<th>Cost Source</th>
<th>Lockheed Martin–Fort Worth</th>
<th>Lockheed Martin–Marietta</th>
<th>Lockheed Martin–Palmdale</th>
<th>Northrop Grumman–Palmdale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Permits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permit to construct and new source review (nonrecurring expenses)</td>
<td>$50,000 for hush house</td>
<td>$50,000 for paint facility</td>
<td>$10,000 for paint facility</td>
<td>$10,000 for hush house</td>
</tr>
<tr>
<td></td>
<td>$50,000 for hush house</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permit to operate (recurring expenses)</td>
<td>No additional fees for FACO</td>
<td>No additional fees for FACO</td>
<td>$500 per year for paint facility</td>
<td>$200 per year for hush house</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$200 per year for hush house</td>
<td>$200 for appliqué area</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$200 for appliqué area</td>
<td></td>
</tr>
<tr>
<td>NEPA Analyses (nonrecurring)</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$160,000</td>
<td>$160,000</td>
</tr>
<tr>
<td>California Environmental Quality Analyses (nonrecurring)</td>
<td>N/A</td>
<td>N/A</td>
<td>Included in $10,000 permit</td>
<td>Included in $10,000 permit</td>
</tr>
</tbody>
</table>

*aExpenses may apply if any new construction or extensive modification to existing structures is required. Expenses should be applied only once, and cover analyses for any combination of new construction.*
### Table 7.4
**Summary of Air Emissions and Control Costs**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Nonrecurring Costs(^a)</th>
<th>Recurring Costs(^b)</th>
<th>Emissions Banking System</th>
<th>Flex-Permitting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockheed Martin–Fort Worth</td>
<td>$110,000</td>
<td>$0</td>
<td>Yes—credits expire after 60 months, if banked after January 2, 2001; 120 months if prior to January 2, 2001</td>
<td>Yes</td>
</tr>
<tr>
<td>Lockheed Martin–Marietta</td>
<td>$160,000</td>
<td>$31 per ton over emissions thresholds</td>
<td>Yes—credits do not expire, but they do depreciate</td>
<td>No</td>
</tr>
<tr>
<td>Lockheed Martin–Palmdale</td>
<td>$180,000 plus $20,000,000 if new or extensively modified paint facility required(^c)</td>
<td>$900 + $2,000,000 if new or extensively modified paint facility required(^c)</td>
<td>Yes—credits do not expire or depreciate</td>
<td>No</td>
</tr>
<tr>
<td>Northrop Grumman–Palmdale</td>
<td>$170,000 + $10,000,000</td>
<td>$400</td>
<td>Yes—credits do not expire or depreciate</td>
<td>No</td>
</tr>
</tbody>
</table>

\(^a\)Nonrecurring costs include equipment investment costs, NEPA analysis, and permitting costs.

\(^b\)Recurring costs include annual equipment operations and maintenance, inspection, and annual fees.

\(^c\)$20 million control technology and associated maintenance costs may not be required if extensive use of appliqué and water-based paints substantially reduces VOC emissions during painting. However, we cannot definitely assert that improved technology will be available by the time production starts.
Fort Worth

The primary costs at Lockheed Martin’s Fort Worth site are associated with permits to construct and New Source Reviews (NSRs), and, because the plant is government-owned and contractor-operated, the requisite NEPA environmental analysis must be performed. An NSR is needed to construct a hush house, if required, while the NEPA analysis is required to address the construction of the hush house and paint facility, as well as the modification of a historical building at the facility. These nonrecurring costs total $110,000. Because the Lockheed Martin facility in Fort Worth has a Flexible Air Permit from the state of Texas, it is allowed to construct a new eight-bay paint facility under its existing air permit, provided the new facility meets the control technology standards as required by the permit. It is Lockheed Martin’s assessment that an NSR will not be required for the paint facility.

Annual inspection costs to ensure compliance with air emissions regulations are $12,500 for the Fort Worth facility as a whole. However, these costs will be incurred with or without FACO. Thus, the additional inspection and maintenance costs stemming from FACO are zero.14

The Flexible Air Permit also allows Lockheed Martin to increase air emissions up to a facilitywide cap. Lockheed Martin can emit up to 372 tons of VOCs per year without any additional controls being installed. This contrasts with Palmdale, where Best Available Control Technology (BACT) will need to be installed on a new or extensively modified paint facility even though emissions remain below the facility cap.

Marietta

Nonrecurring costs in Marietta are similar to those Lockheed Martin would require at Fort Worth, because both sites are government-

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owned and contractor-operated and fall under NEPA requirements.\textsuperscript{15} However, because Georgia does not offer Air Flexibility Permits, Lockheed Martin assumes an additional $50,000 for NSR of the paint facility. Georgia’s annual fees associated with the Title V permit are considerably lower than those in Texas. Lockheed Martin has worked with the state of Georgia extensively to streamline its permitting process, with one permit covering the entire facility. The fees must be paid with or without FACO, however, so no incremental operating permit costs arise from FACO.

As is the case with Fort Worth, Marietta is in a serious nonattainment area and must offset increases in emissions once facilitywide emissions exceed certain levels. These thresholds are 100 tons per year for VOCs, 50 tons per year for NOx, and 100 tons per year for particulate matter. Lockheed Martin reports that, even with JSF FACO, VOC emissions will not exceed the 100-ton threshold, thus no emissions offsets would be required. NOx emissions currently exceed the threshold, so additional emissions arising from FACO must be offset. Emissions can be offset in two ways. First, Lockheed Martin can reduce emissions from existing sources. This could be accomplished by installing new non-FACO emissions-control equipment or by reducing non-FACO production at the site. Second, Lockheed Martin emissions can be offset by buying credits through Georgia’s Emissions Banking Program.\textsuperscript{16} If Lockheed Martin were unable to procure credits, it would have to pay $31 per ton of emissions over the threshold. Because Lockheed Martin plans to install new production technology—indepen dent of FACO—that will reduce NOx emissions from other production programs at the site,\textsuperscript{17} we do not

\textsuperscript{15}According to Lockheed Martin, much of the equipment used for the F-22, such as the hush house and paint facilities, could be converted to handle the JSF. However, modifications will be extensive enough to require new source review.

\textsuperscript{16}This emissions banking program in Georgia is modeled on the Texas emissions banking system, but, unlike in Texas, emissions credits in Georgia do not expire. Credits in Georgia are discounted after a certain period: 20 percent for VOCs and 30 percent for NOx. At the Fort Worth facility, the credits banked must be used within 60 months from the day they are awarded, if banked after January 2, 2001. Any credits awarded on or before January 2, 2001, must be used within 120 months from the time they were awarded (Texas Administrative Code, Title 30, Part 1, Chapter 101, Subchapter H, Division 1, Rule §101.302(d)(2)).

\textsuperscript{17}Lockheed Martin is planning to replace two old boilers, which will substantially reduce NOx emissions at the site.
Environmental Costs

expect Lockheed Martin will need to buy emissions credits or pay fines for FACO production.18

Lockheed Martin–Palmdale

The major difference between Lockheed Martin’s facilities in Palmdale and its facilities in Texas and Georgia is that in Palmdale it must install BACT if a new paint facility is constructed, while at the other sites emissions credits can be used to offset the emissions that would be eliminated by BACT. BACT must also be installed if an existing paint facility is used for JSF FACO and the emissions-control equipment is extensively modified. Antelope Valley Air Quality Management District (AVAQMD) regulations require BACT for sources that emit more than 25 lbs of VOC per day (which translates into 4.6 tons per year). Emissions from the paint facility exceed this limit based on experience from past aircraft. Note, however, that if appliqué or water-based paints are used extensively, VOC emissions might not exceed the VOC cap. Absent information on how extensively water-based paints or appliqué will be used, we assume that VOC emissions will exceed the BACT requirements. Because we also do not know if pollution-control regulations will become stricter in the next few years (which may require a new paint facility, in any case), this is a reasonable approach.

Lockheed Martin reports that existing paint facilities cannot be used for FACO. It estimates that a control device that can handle 650 cubic ft per minute for a new facility will cost $20 million.19

18If the Cobb County region’s air quality continues to deteriorate, forcing it to become a severe nonattainment area, then the credits Lockheed Martin has banked would allow the company to continue operation without immediate increase in costs. Also, according to Lockheed Martin environmental experts and Georgia Air Protection Branch officials, Lockheed Martin should be able to use emission credits to offset and minimize any additional emission regulations arising from other future New Source Reviews required for the FACO process (discussions with Scott Fetter, Lockheed Martin, and Terry Johnson, State of Georgia Department of Natural Resources, Environmental Protection Division, Air Protection Branch).

19According to Lockheed Martin, options for BACT on the paint facility include thermal oxidation (incineration), activated carbon fluidized bed, ultraviolet/ozone, system, and zeolite rotary concentrator. Lockheed Martin reports capital costs range from $20–50 per cubic foot per minute of air flow. For 650,000 cubic ft per minute, this range translates into $13.0–32.5 million. Lockheed Martin’s $20 million estimate is roughly the midpoint of this range.
Martin also estimates that operation and maintenance costs for this control device will amount to $2 million per year (see Table 7.2). These costs would not be incurred at Fort Worth or Marietta.

With respect to engine noise, NSR will be required for the hush house if engines are tested before installation. Once installed in the aircraft, the engines are considered mobile sources and are not subject to regulation by the AVAQMD. The U.S. Environmental Protection Agency (EPA) sets regulations on aircraft. Lockheed Martin reports that it plans to test seven engines per year in the hush house before installation. This testing will trigger NSR; we include the costs for this in our analysis.

Emissions at the Palmdale plant exceed the thresholds that trigger offset requirements for new emissions. The additional emissions from the paint facility and uninstalled engines may be offset by using emissions credits banked at the facility or by buying new credits. The Lockheed Martin facilities in the Palmdale area (Plant 10 and Sites 2 and 7 on AFP 42) have an overall emissions cap of 625 lbs per day (114 tons per year) for VOC. The cap does not expire or depreciate. Current VOC emissions are far below the cap, and the added VOC emissions from JSF FACO will fit under the cap. According to Lockheed Martin, existing credits are also available to offset NOx emissions from uninstalled engines. If credits are not available at the site, Lockheed Martin may be able to buy credits through a market for emissions-reduction credits. Credits can be purchased from firms or brokerages in the neighboring South Coast Air Quality Management District. However, the purchase of credits is associated with unpredictable risk about their availability and price.

Environmental planning and permitting covered under NEPA requires an Environmental Assessment (EA) followed by a more-

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20 In the AVAQMD, offsets for new emissions must be obtained for facilities emitting more than 25 tons per year of VOC, 25 tons per year of NOx, or 100 tons per day of PM10.
21Bret Banks, operations manager, AVAQMD, personal communication, February 2002.
22Alan DeSalvio, air-quality engineer, AVAQMD, personal communication, February 2002.
23Automated Credit Exchange in Pasadena, Calif., is an example of such a brokerage.
extensive Environmental Impact Statement (EIS) if the EA indicates significant issues. Lockheed Martin anticipates that an EA for Fort Worth and Marietta will result in a Finding of No Significant Impact from JSF production’s merely replacing decreasing F-16 and F-22 production. An EA for Palmdale will be problematic because no significant legacy aircraft production offsets the new environmental emissions from JSF production. With the lack of legacy infrastructure, Lockheed Martin anticipates conducting both an EA and EIS, which it estimates will cost $160,000.

**Northrop Grumman–Palmdale**

At Northrop Grumman’s Palmdale facility (Sites 3 and 4 on AFP 42) a building has been permitted as a paint facility and is currently used for depainting. Northrop Grumman reports that it could move the depainting to another building and use the first building for FACO painting. Using a building already permitted for painting would mean that Northrop Grumman would not need to install BACT. The company estimates that it will cost $10 million to install depainting equipment in another facility on the site and to convert the building currently used for depainting to painting.

There are two hush houses on the Northrop Grumman site that could be used for JSF FACO. If uninstalled engines are tested in them, permits must be obtained; we assume this will cost the same as reported for the Lockheed Martin–Palmdale site. Northrop Grumman may be able to test the engines at other nearby facilities, but, for the purpose of our analysis, we assume that the entire FACO process would be done on the Northrop Grumman site.

The availability of a paint facility on the Northrop Grumman site raises the question of whether Lockheed Martin–Palmdale could lease Northrop Grumman paint facilities. Doing so could cut roughly $10 million from the costs of FACO at the Lockheed Martin–Palmdale site. A number of hurdles must be overcome for Lockheed Martin to use Northrop Grumman facilities, however. Environmental liability related to air and wastewater discharges are substantial. Issues related to security around the Northrop Grumman B-2 facilities on the site would have to be addressed. Finally, there would be workers’ compensation issues related to Lockheed Martin personnel working on the Northrop Grumman site that would have to be addressed.
principle, these issues could all be resolved, but resolution is not guaranteed. Resolving these issues would take time, and might generate substantial negotiation costs. In our analysis, we calculate costs assuming FACO is done entirely on the Lockheed Martin–Palmdale site or the Northrop Grumman–Palmdale site, but cost savings from sharing facilities across the two sites merit consideration.

INTANGIBLE ENVIRONMENTAL ISSUES

Several other factors may ultimately affect environmental compliance costs and schedule at the site, but the relationship to cost is neither clear nor direct. These factors include the level of community activism and acceptance, overall regulatory atmosphere (which includes innovation, complexity, industry and government cooperation, and flexibility), and enforcement aggressiveness.

Community Activism

Community activism has delayed and even terminated projects in the past. Therefore, it is important to assess how the community accepts its corporate neighbor and whether the corporation engages and informs the public about environmental concerns or projects the company is undertaking that could change the surrounding environment.

Lockheed Martin has taken an active role in all three communities and reportedly has worked hard to maintain good corporate-government relations as well as good community relations. Such an investment in community relations has paid off in support for the JSF program in each community. Data and interviews with local officials and journalists have confirmed this assessment. At all three potential locations, environmental activism directed toward the activities undertaken or the indirect consequences of these activities—e.g., increased noise, air pollution—was negligible. For example, the Air Force is rectifying contaminated groundwater in Palmdale. Despite these environmental problems and the public concern over the safety of the drinking water, there seems to be no publicly perceived linkage to the envisioned JSF FACO process and existing groundwater contamination issues. Moreover, AFP 42, which includes North-
rop Grumman, has established an environmental issues board that addresses potential environmental concerns of the community. Through this board, the plant has been able to establish a good relationship with the community. In Texas, Lockheed Martin has also maintained a solid civic relationship with the Fort Worth community. Conversations with the chairman of the Sierra Club’s Dallas–Fort Worth chapter and other activists connected with the environmental conditions of the area were all positive about Lockheed Martin’s relationship with the community over the past decades. In Marietta and the surrounding areas, jet noise associated with the Lockheed Martin aircraft manufacturing facility has not been an issue since Lockheed began manufacturing aircraft there over 50 years ago. In fact, the only type of complaint involving noise during that time has involved Air National Guard jets flying over residential areas.

**Regulatory Atmosphere**

States vary in the way they regulate environmental practices beyond what is required on the federal level, as well as in the complexity of the environmental regulations. States where sites are being considered have different regulatory atmospheres that could affect costs for the overall FACO process. Texas and Georgia state regulations, for the most part, are consistent with federal environmental regulations, which have established a floor for environmental compliance. California has enacted environmental regulations that, in many cases, go beyond federal requirements to contend aggressively with the pollution problems the state currently faces.

The complexity of environmental regulations is a factor because the more complex an environmental regulatory program, the greater the opportunities for failure or mistakes on the part of companies trying to comply. Theoretically, regulatory complexity could affect costs of the overall FACO process because achieving or maintaining compliance with stringent or complex state environmental regulations might lead to significant fines or temporary plant shutdown. The number of permits required at each of the sites being considered reflects the complexity of the regulations in each state. Lockheed Martin–Palmdale currently has 172 air permits for its site, compared
with 2 at the company’s site in Fort Worth and 13 at Marietta. Northrop Grumman has 45 permits in Palmdale.\textsuperscript{24}

While California tends to have additional and more-complex regulations than either Texas or Georgia, Lockheed Martin’s and Northrop Grumman’s longtime presence in the Antelope Valley and understanding of these regulations should help them avoid any of the aforementioned challenges posed by a more-complex regulatory environment. In Georgia and Texas, the levels of resources invested and systems implemented by Lockheed Martin for addressing environmental issues and its good relations with state enforcement agencies mean that regulatory problems will most likely not adversely affect the company in terms of plant shutdowns or lead to significant additional costs incurred associated with violations.

Another way for a company to address challenges posed by state environmental regulations and compliance requirements is through environmental management innovations. An environmental management system (EMS) is integrated into an organization’s overall management process, identifying policies, environmental goals, measurements, authority structures, and resources necessary to achieve compliance with environmental regulations, as well as attain a level of environmental performance that goes beyond minimal compliance. In some cases, the state government works with companies to help them develop EMSs. Lockheed Martin has operated a formal EMS since 1992. The system combines occupational health aspects and environmental compliance and pollution prevention. It also allows for the development of government-corporation communication channels to monitor compliance with regulations, reducing the risk of noncompliance. Lockheed Martin–Fort Worth is currently certified by an independent third-party body to ISO 14000 standards. In 1998, Lockheed Martin–Palmdale declared itself in conformance with ISO 14001 Standard and maintains a corporatewide EMS program. For both its Palmdale and Marietta sites, Lockheed Martin is in the process of seeking third-party certification to the standard. By 2004, all sites are anticipated to be certified.\textsuperscript{25}

\textsuperscript{24}Permit information is from DCMA data.
\textsuperscript{25}Discussion with Lockheed Martin environmental personnel. Fort Worth is already third party certified. Palmdale is seeking third-party (currently self-certified); Marietta
Enforcement Aggressiveness

Statutory authority that allows state enforcement agencies to assess penalties varies from state to state and could affect the amount of the penalty and time it takes to levy—factors that could affect cost. Both Texas and Georgia have administrative order authority, which allows enforcement agencies to fine violators without pursuing legal action. California is in the midst of a regulatory reform that will provide such authority to certain enforcement areas. But currently no plan exists to give administrative order authority to one of the most significant enforcement agencies: air-quality management districts. A combination of aggressive enforcement and more legal enforcement mechanisms could lead to a more drawn-out penalty process if violations are significant. Enforcement authority could also affect frequency of inspections because enforcement authorities in states without administrative order authority are less inclined to make numerous visits if their only recourse to achieve compliance or assess fines is through the courts.26 Based on its experience with Lockheed Martin, California has tended to follow this pattern, with more-aggressive, but less-frequent, site inspections than the Fort Worth or Marietta site. However, given Lockheed Martin’s ability to comply with state and local environmental regulations, aggressive enforcement should not be an issue.

SUMMARY

From the perspective of environmental costs, the primary difference between the sites is the cost of controlling air emissions. Air pollution is worse in the Palmdale area than it is in Fort Worth or Marietta, and more-stringent air pollution control equipment is required in Palmdale. VOC emissions during the FACO painting process are the major source of concern. No existing paint facilities at the Lockheed Martin–Palmdale site can be used for FACO. The emissions-control technology required on a new paint facility would cost an estimated $20 million to install and $2 million per year to operate and main-

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26GAO, 2000, p. 40.

is also seeking third-party certification. Within two years, all sites will be third-party certified.
tain. These costs need not be incurred at Fort Worth or Marietta. Existing paint facilities are available at the Northrop Grumman site, so new air pollution control equipment would not have to be installed there. However, it would cost an estimated $10 million to reconfigure existing facilities at the site to accommodate FACO painting. Lockheed Martin–Palmdale could, in principle, use Northrop Grumman paint facilities, but a number of security, environmental, and workplace safety issues would likely be difficult to resolve.

If paint technology or the use of appliqués for the JSF evolves over the next five years during SDD, currently required pollution control investments might be avoided. However, pollution standards might be tightened during the same period. We follow a conservative approach and assume that investments will be required.

There is no basis to prefer one site over another based on community and nongovernmental organization activism, previous violations, or the relations the facilities have with the community. No location has environmental costs significant enough to make a compelling case for not locating FACO there. Although the Palmdale site may be at somewhat of a disadvantage in terms of regulatory atmosphere and enforcement aggressiveness, it appears that, while adding some risk, any California-specific issues in these areas are manageable.