INTRODUCTION
The impact of foreign object debris (FOD) remains a major concern in the aviation, defense, and space industry and is viewed as a major potential source of risk (condition + action) by regulators and customers. Lack of FOD prevention often leads to significant problems with the quality or cost of delivered product and ultimately threatens people’s lives. The degree of risk for a supplier to introduce FOD in the workplace is dependant on the nature of the supplier’s processes.

PURPOSE
The purpose of this document is to outline fundamental approaches and provide basic guidelines for suppliers in the aviation, defense, and space industry to assess their processes and establish /implement a FOD prevention program. As NOT all guidelines contained in this section will apply to all suppliers, the intent is NOT to establish FOD requirements for suppliers. Rather, it is to provide effective means for suppliers of aviation, defense, and space products to develop FOD prevention measures and policies through a baseline FOD procedure, FOD checklists, an interactive FOD prevention training package, and a risk-based FOD assessment process. The aim is to prevent the occurrence and risk of FOD and improve the quality of industry suppliers by sharing best practices.

The processes and guidelines outlined in this section are based on NAS 412, the National Aviation, defense, and space Standard (NAS) baseline FOD prevention policy/procedure of the Aerospace Industries Association (AIA). NAS 412 supports AS/EN/JISQ 9100, the quality management system standard which requires suppliers to carry out a program for the prevention, detection, and removal of foreign objects from its products.

WHAT IS FOD?
Foreign Object Debris (FOD) – A substance, debris, or article alien to the component, assembly, system or vehicle that could cause damage.

Foreign Object Damage (FOD) – Any damage or incident attributed to a foreign object that can be expressed in physical or economic terms that may or may not degrade the product’s required safety and/or performance characteristics. Examples of foreign object debris include items such as: work tools, drill bits, assembly parts, machining chips and scrap, and assembly process debris. Other potential FOD include personal items such as: food and beverages, loose coins, jewelry, buttons, pens, pencils, paperclips, keys, or cell phones. FOD can be generated by machines, processes, environment, or people.

The results of foreign object damage can be catastrophic. Foreign object damage can result in unplanned landings, premature wear of seals causing leaks, premature wear of internal components, and failure to retract landing gear. Foreign object damage is the result of foreign object debris.

FOD prevention and elimination practices are implemented throughout all phases of the manufacturing process including design, machining, assembly, testing, inspection, packaging, shipping & receiving, and repair, including Facilities and Services operations. Successful FOD programs have active participation and commitment from all levels.
of employees. FOD prevention is everyone’s responsibility.

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BASIC ATTRIBUTES OF A FOD PREVENTION PROGRAM

Establishing and maintaining an effective FOD prevention program involves using a “continual improvement” cycle approach that proactively addresses the events (conditions and actions) leading to FOD (see diagram below). Organizations vary in their method of implementing this approach.

Figure 1: Continual Improvement Cycle

FOD PROCESS ASSESSMENT STEPS

These steps define the cycle of continual improvement shown above and will help define the appropriate level of control for the product and/or services you provide. The cycle addresses all aspects of improvement including preventive & corrective actions and monitoring effectiveness.

1) Perform Part Family Risk Assessment (refer to the FOD section of the SCMH)
2) Perform FOD Program Robustness Assessment (Based on results of step 1) (refer to the FOD section of the SCMH)
3) Perform Gap Assessment
4) Implement Closure Plan
5) Re-Assess (To evaluate effectiveness)

As shown in Figure 1, part family risk-based assessments and FOD assessments can determine the degree of risk for a supplier to introduce FOD to a product and determine and categorize the maturity level of a FOD Program. The part family risk assessment measures design characteristics, process characteristics and history of FOD events associated with the source.

Preventive Actions
Monitor Effectiveness
Corrective Actions

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Following the assessments, gaps are identified between current and potential performance using a gap analysis process. Such performance gaps are defined and mitigated for manufacturing and assembly processes. Combined with a comprehensive FOD training program, FOD checklists, audits, and other tools are used to measure a supplier’s ability to recognize and close such gaps in their FOD prevention program. Results of such assessments are utilized to create quality metrics, drive corrective action, support key FOD practices of 1) Prevention, 2) Cleaning, and 3) Detection, support re-assessments, and maintain the cycle of continuous improvement (see Figure 1).

Basic elements or attributes of a FOD prevention program can include the following to ensure product quality and process integrity:

- FOD Prevention Awareness/Training
- Designation/Marking of FOD Prevention Areas
- Parts Protection/Material Handling
- General Housekeeping
- Reporting/Investigation
- FOD Management & Leadership
- Assembly, Manufacturing, & Facilities Processes
- Tool Accountability/Control
- Measuring Performance/Metrics
- Communications/Feedback
- Consumables Accountability
FOD PREVENTION AWARENESS / TRAINING

Suppliers should maintain a FOD prevention program that increases awareness to the causes, effects, and dangers of FOD, promotes active involvement through specific FOD prevention measures and techniques, and stresses good work habits through work disciplines. These attributes are attained and enhanced through a comprehensive training program. The training program should include the following minimum requirements:

a. Establish FOD awareness campaigns and training requirements as applicable, in accordance with the supplier's Quality Management System and FOD plan requirements, as deemed necessary
b. Provide certification training to address area-specific FOD prevention activities, processes and procedures, as required
c. Provide employees ongoing FOD training and visibility to FOD metrics that supplier will track
d. Verify timely completion of FOD training for new, relocated or transferred personnel
e. Review and update the FOD prevention training program periodically to address new capital purchases and/or process changes
f. Make FOD prevention training materials readily available to employees
g. Address all aspects of FOD prevention including but not limited to: proper storage, shipping and handling of material, components, and equipment; foreign object debris control techniques; housekeeping; cleaning and inspection of components and assemblies; tool and hardware accountability and control; control of personal items, equipment, and consumables; identification of high risk areas; and FOD incident reporting procedures.

DESIGNATION / MARKING OF FOD PREVENTION AREAS

FOD prevention will generally fall into one of the following three areas: FOD Critical, FOD Control, or FOD Awareness. FOD Critical areas are those areas at the highest risk for potential FOD incidents. Exposure to foreign objects in these areas would potentially cause system or product failures due to deterioration, malfunction, or damage. Examples are critical production & test areas, overhaul & repair / modification areas, and flight line areas.

FOD Control areas are those in which there exists a high potential for FOD entrapment and migration to the final product. Examples are assembly and test areas.

FOD Awareness areas are those production-related areas that have a low potential for FOD entrapment or FOD migration. Examples include areas with a part of the production operations that does not directly involve assemblies, components, or parts like machining, grit blast, tumbling.

To keep personnel conscious of FOD, all production operations areas should be identified with the above designations using readily visible signs, floor markings, barriers, etc., to define the level of that area.

PARTS PROTECTION / MATERIAL HANDLING

The supplier should have an effective plan for material handling and parts protection. This plan should include the following provisions:

a. Only approved packaging and handling materials and accessories in proper condition, clean and free of contamination or loose items such as paper, wood chips, screws, mounting hardware, etc., should be used
b. Proper care and maintenance of plant materials and equipment should be implemented to prevent the potential for FOD
c. A policy is in place to pick up dropped or fallen parts and other items immediately
d. Openings on parts that lead to entrapment areas shall be covered if not being actively worked

e. Secure loose parts in storage containers, racks, and fixtures

f. Use labels for easy identification

g. Use caps and covers in proper condition, and be cautious that caps and covers need to be controlled as well as they often can pose FOD risks themselves if allowed to invade the product

GENERAL HOUSEKEEPING

The Supplier should maintain clean and FOD-free receiving, maintenance, manufacturing, operational, and shipping areas. General 6S (sort, shine, straighten, standardize, sustain and safety) principles should be applied during daily operations. A “clean-as-you-go” policy should be established and maintained. Housekeeping guidelines should be established for serviceability, storage, and cleanliness of tools and/or materials. Housekeeping practices should include the following:

a. Keep work stations and work areas neatly organized

b. Immediately dispose of trash in proper trash receptacles

c. Ensure all tool storage receptacles are clean and debris free

d. Do not leave tools unattended

e. Pick up and dispose or remove any FOD or potential FOD in work areas on sight

f. Conduct regular FOD walks of manufacturing or assembly areas

REPORTING / INVESTIGATION

All incidents of actual, potential, or near miss FOD at a supplier site should be reported, investigated, analyzed, and documented for appropriate feedback and action. It is the responsibility of every employee to report a lost tool or other item. When a FOD incident occurs, operation should immediately cease and an investigation initiated.

FOD reporting/investigation processes and procedures should include the following:

a. A documented process / procedure to report, investigate, and track actual, potential, or near miss FOD incidents

b. Investigation should start with cessation of work, securing the area so as not to disturb evidence or cause further damage, and photographing and capturing evidence for analysis

c. Timely implementation of a post-incident root cause analysis and determination of corrective action to prevent similar occurrences in the future

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d. Communication of FOD incidents to all affected personnel to facilitate feedback and lessons learned

FOD MANAGEMENT & LEADERSHIP

The supplier should have a designated FOD Prevention Focal, responsible for the development and implementation of plans and programs to prevent hardware damage covering all production areas. Employees should be aware of their FOD Prevention Focal and know how to contact this person if needed. The FOD Prevention Focal should have the authority and freedom to identify and implement FOD prevention measures and achieve continuous improvement.

Responsibilities of the FOD Prevention Focal should include:

a. Chair and maintain a FOD Prevention Committee

b. Establish and manage supplier site FOD prevention plan activities including audits of work areas and FOD prevention effectiveness

c. Oversee overall implementation of the supplier’s FOD Prevention Program

d. Communicate all FOD procedures, requirements, and processes to the FOD prevention committee and to all employees at the supplier

e. Review and assess area FOD metrics and incident reports

f. Provide visibility of FOD prevention activities, area performance (metrics), and program status
g. Assist in the investigation and resolution of FOD incidents and recommendation of preventive measures
h. Establish formal documentation, as necessary, to detail area specific procedural requirements
i. Ensure FOD prevention training is maintained and available for employees and assist in the development and delivery of training curricula
j. Perform a planned, periodic, recurring audit (reference sample checklists) to check implementation of FOD requirements
k. Approve work restart after a stoppage due to a FOD incident

ASSEMBLY, MANUFACTURING, & FACILITIES PROCESSES

The supplier should plan and sequence production operations to preclude and prevent the occurrence of FOD. Documented work instructions for such operations should contain process and procedures for the control and removal of contamination and debris during fabrication and assembly operations, as well as FOD inspections prior to the start and upon completion of each production operation.

TOOL ACCOUNTABILITY / CONTROL

Employees are to actively engage in practices that will eliminate accidents/incidents and loss of life or equipment due to tool FOD. Tool control is an easy way to prevent the risk of tools becoming FOD and damaging product. A good tool control program not only accounts for tools but monitors the condition of the tools. Tool accountability and control processes and procedures include such techniques as:

a. Documented processes and procedures for effective tool accountability and control (i.e. check-out, check-in of tools and toolboxes) including a search and recovery effort for missing tools and/or items
b. Tool control & storage techniques such as: shadow boards, shadowboxing, bar coding, controlled tool boxes, inventory checklists, tethered tools and equipment, tote trays, tool bags, tool counters, chit system, tool tags, consolidated tool kits, special canvas layouts with tool pockets, and spill-proof containers, etc
c. Unique control methods are established for special tools used in checkout, test, and operational environments
d. Each tool storage location is uniquely identified by number, and tools are marked with storage location
e. Tools are inventoried on regular basis, such as start and end of each shift
f. A policy whereby only company-provided tools and equipment should be provided unless specified and approved
g. A periodic review of perishables (e.g. drill bits, cutters, reamers, and other items requiring replacement in time due to wear) or broken tools

MEASURING PERFORMANCE / METRICS

Suppliers should maintain visibility of FOD prevention performance with a variety of methods including visibility charts, trend analysis, report cards, performance reviews and/or customer comments, concerns, or complaints. Such items should be used to identify problem areas and trends, inform management and workers, and measure progress. Metrics should be used to measure the quality of the supplier’s FOD prevention program, displayed for workforce knowledge, and used to drive continuous improvement and corrective action. Effective metrics should be established to monitor performance, identify process deficiencies, and measure effectiveness of the FOD prevention program.

COMMUNICATIONS / FEEDBACK

FOD awareness is the key to an effective FOD prevention program. The active flow of FOD information throughout the company is essential to establish and maintain a heightened level of FOD awareness. FOD alerts are awareness tools used highlight past events or potential threats. Examples of FOD alerts include:

a. FOD metrics
b. FOD prevention posters
c. Notices in affected work areas and common areas identifying critical concerns

FOD awareness promotes safety by reducing debris clutter, loose tools, and unnecessary materials in the workplace. It is an integral part of production quality.

CONSUMABLES ACCOUNTABILITY

Consumables are regarded as potential FOD items and should be handled in the same manner and with the same level of caution as tools and hardware, with respect to FOD prevention measures. Consumable items include tongue depressors, wipes, rags, sandpaper, brushes, applicators, scrapes, glue, paint, sealant, safety wire, tape, and other expendables. Consumables accountability should include the following practices:

a. Take only the minimum amount required to complete a task
b. Use company-provided containers to transport consumables
c. Report, investigate, and document all lost consumables in accordance with FOD reporting/investigation procedures
d. Keep consumables outside of controlled areas

HARDWARE ACCOUNTABILITY / CONTROL

Employees are to actively engage in hardware (i.e. nuts, bolts, screws, tubes, cotter pins, rivets, fasteners, etc.) control. Effective methods for hardware accountability include:

a. Taking only what is needed to perform tasks in a work area
b. Implementing beginning and ending inventory checks of consumables, expendables, and assembly hardware in high risk FOD areas
c. Kitting, sorting, and labeling hardware by task
d. Placing foreign object containers and cones in key locations within the work area and at entry and exit points to collect loose parts found
e. Practicing the "clean-as-you-go" concept
f. A tracking system for loose parts
g. Furnishing and specifying the use of tote trays and covered spring-loaded containers
h. Knowing what was used to perform a task and how much should be left

PERSONNEL CONTROL

FOD prevention is the responsibility of all personnel involved in the assembly, integration, test, manufacturing, storage, installation, operations, modification, delivery, process support, construction and maintenance of products and the facility.

To uphold FOD prevention responsibilities all employees should:

a. Certify completion of FOD training for all personnel who access FOD areas.
b. Have a process to share ideas to improve the FOD prevention program
c. Ensure all tools, parts, shop aids, personal items, and consumables are accounted for and contained in pouches, totes, etc., when in, on or within near proximity of the product
d. Familiarize themselves with FOD prevention forms and procedures (for recovered items, lost items, near miss, etc)
e. Wear attire appropriate for the relative FOD level in which they work (such as lint free white cotton overalls, head covering, and shoe covers)
f. Remove all loose objects, badges, jewelry, etc. from clothing as required by area definition
g. Observe all marked FOD control areas, signs, floor markings, or stanchions and follow the respective FOD procedures and guidelines
h. Refrain from consumption of food or drink in work areas
i. Monitor that visitors in FOD critical and FOD control areas have received FOD training or must remain under escort.
all times. Escorts are responsible for ensuring visitor compliance of FOD prevention requirements. Vendors and contractors must adhere to all FOD prevention program rules and guidelines.

DESIGN CONSIDERATIONS
The supplier should establish processes and procedures to minimize the potential for damage and FOD hazards and facilitate FOD prevention awareness with regard to design and planning considerations.

Examples of general design considerations with respect to FOD prevention should include:

a. Identifying and eliminating FOD entrapment areas
b. Identifying and sealing potential FOD migration areas
c. Use of screens, plugs, covers, etc. over exposed openings when appropriate
d. Installing special access panels or ports for removing FOD
e. Use of blind or self-retaining fasteners when appropriate
f. Use of compatible metals and seals to prevent accelerated deterioration and the potential for FOD
g. Minimizing moisture entrapment areas
h. Minimizing the potential for chaffing through the use of brackets, special protective material, or special wire / cable routing

GLOSSARY
Clean-as-you-go
A general practice of cleaning the immediate area to eliminate debris that could become entrapped in closed spaces and cause damage to an aircraft, component, or assembly.

Consumables
Expendable supplies provided to workers generally discarded after use.

Expendables
Items used during the manufacturing process that become non-functional after extended use (tongue depressors, wipes, rags, sandpaper, brushes, applicators, scrapers, glue, paint, sealant, etc.).

Foreign Object
A substance, debris, or article alien to a vehicle or system that could cause foreign object damage.

FOD Critical Area
An area where flight hardware is in place and exposure to foreign objects would potentially cause a system or product failure due to deterioration, malfunction, or damage.

FOD Control Area
An area in which there exists a high potential for FOD entrapment and migration to the final product.

FOD Awareness Area
Those production-related areas that have a low potential for FOD entrapment or FOD migration.

FOD Incident
An occurrence of damage, or the potential for damage, or the service life impairment/operation restriction to an aircraft, major assembly, component, or system attributed to debris.

FOD Incident Report
A report containing specific information about the incident, as discovered, and the corrective action taken.

Near miss
A FOD incident which would have occurred had it been undetected.

Potential FOD
The condition where foreign object debris may cause damage and/or failure should the product be put into use.
Product
(See AS/EN/JISQ 9100 for definition)
Tether
A lanyard of sufficient length attached to the tool/equipment and to the user or fixed secure object.
Tool
Any handheld device that aids in accomplishing a task (screwdriver, Allen wrench, fixtures).
Tote tray
A device for storing / carrying / transporting tools or equipment in a secure manner.