



# NASA-STD-3000 Man-Systems Integration Standards

## Volume I, Section 13

### 13 FACILITY MANAGEMENT

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This section contains the following topics:

13.1 [Introduction](#)

13.2 [Housekeeping](#)

13.3 [Inventory Control](#)

13.4 [Information Management](#)

#### 13.1 INTRODUCTION

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This section provides the design considerations, requirements, and examples for the facility management functions of housekeeping, inventory control, and information management.

#### 13.2 HOUSEKEEPING

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##### 13.2.1 Introduction

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This section addresses the design considerations, design requirements, and example design solutions for housekeeping. This includes design for ease of cleaning, decontamination, servicing, and on-orbit repair.

Refer to the following paragraphs for other housekeeping topics:

Chapter 5, 5.1.3 - Long-Term Mission Atmosphere Design Requirements

Chapter 10, 10.5.3.4 - Galley and Wardroom Cleaning Design Requirements

Chapter 10, 10.10.3 - Laundry Facility Design Requirements

Chapter 10, 10.11.3 - Trash Management Facility Design Requirements

Chapter 10, 10.12.3 - Stowage Design Requirements

Chapter 13, 13.4.3 - Information Management Design Requirements

## 13.2.2 Housekeeping Design Considerations

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Housekeeping is a crucial part of habitability. It plays an important role in maintaining the crew's health and safety and, consequently, their morale, comfort, and productivity. Manned spacecraft with missions of long duration increase the need for housekeeping capabilities.

The principal sources of microbes, chemicals, and debris that cause housekeeping problems are the crewmembers (finger nail clippings, hair, dead skin, finger prints, etc.); clothing (lint); food (liquid and solid food spills); maintenance (loose parts, filings, leaks from disconnected valves, etc.); and payloads (animals, chemicals, effluents, etc.). Microgravity causes this debris to migrate and lodge on all surfaces. Cracks and crevices particularly collect debris.

Food and drink spills occur frequently. Cleanup in the Skylab was not easy because of the grid floor as well as other hard-to-get-to spots. The use of a wet rag became the standard procedure for cleaning up the food spills. Food disposal areas caused odors and required frequent cleaning with biocide wipes.

In Skylab, biocide wipes did a satisfactory job, but were tedious to use. Crews prefer a single-step biocide that does not have to be washed off. A handle, holder, or gloves are preferred when using biocide wipes as the biocides stain the hands. An aerosol biocide would be useful. Crews have requested an aromatic disinfectant. Urine spills were cleaned up satisfactorily by biocide wipes. Removal of the urine odor is especially important.

Soft rags are superior to tissue wipes for cleaning up large areas.

Mold and mildew flourish on surfaces that are damp, wet, poorly ventilated, and poorly lit. Therefore, grooming, dining, and food preparation areas should be dried and aired regularly, and should be well illuminated.

A vacuum cleaner was used effectively on the Skylab and the Shuttle. It was used to remove dust, lint, liquids, and debris from surfaces and air filters. It provided for easy removal and disposal of the debris. A vacuum cleaner was used in the Skylab for removing water from the shower walls. Crewmembers have criticized the noise level, the limited suction, and the available attachments. The vacuum cleaning system should be very easy to use. The equipment should be easy to maintain and repair. Disposable vacuum cleaner bags should be easily replaced.

Air revitalization system and air-cooled equipment filters collect various types of debris including tape, lint, hair, small parts, tissues, nail clippings, and food crumbs. The filters require convenient access for them to be cleaned with the vacuum cleaner and for retrieval of small lost items. Vacuum cleaner attachments should be designed to be compatible with the various filter configurations

The greatest practical precautions should be taken to ensure freedom from debris and surface contamination during the manufacturing through launch sequence.

## 13.2.3 Housekeeping Design Requirements

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### 13.2.3.1 General Housekeeping Design Requirements

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All systems shall be designed to minimize the need for housekeeping. The following general requirements shall be observed:

- a. Contamination Control During Ground Handling** - The greatest practicable precautions shall be taken to ensure freedom from debris and surface contamination within the space module and individual systems and components during the ground operations from manufacture to launch.
- b. Surface Materials** - Materials used for exposed interior surfaces shall be selected to minimize particulate and microbial contamination and be easy to clean (i.e., shall be smooth, solid, nonporous).
- c. Grids and Uneven Surfaces** - Grids and uneven surfaces shall either not be used or they shall be easy to remove and easy to clean.
- d. Cracks and Crevices** - All interior structural surfaces and equipment shall be free of narrow openings and crevices that can collect liquid or particulate matter or that require a special tool for cleaning.
- e. Closures** - Closures shall be provided for any area that cannot be easily cleaned.

(Refer to Paragraph 11.4, Closures, for specific design considerations and requirements.)

**f. Fluid and Debris Collection/Containment** - Means shall be provided for collecting and/or containing any loose fluids or debris that may result from operational use, component replacement, maintenance, service or repair.

**g. Built-in Control** - Any subsystem which routinely utilizes containers of liquids or particulate matter shall have built-in equipment/methods for capture or prevention of vaporization into the atmosphere, prevention of material overflow from use, and methods of decontamination of spills.

**1.** The capture elements shall be easily accessed for replacement or cleaning without risk of dispersion of the trapped materials.

**2.** Grid, screen, or filter surfaces shall be directly accessible for cleaning

(Refer to Paragraph 13.2.3.4 Air Filter Design Requirements, for filter requirements.)

**h. Transfer Containers** - Transfer containers, if required, shall be so constructed as to prevent contamination during transfer and disposal.

### **13.2.3.2 Surface Cleaning Design Requirements**

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The following surface cleaning provisions are required:

**a. Microbiological Analyses/Biocide Selection** - A means shall be provided for the collection and identification of microbial samples from all types of surfaces and for the selection and application of an appropriate biocide.

**b. Cleaning Chemicals** - Cleaning chemicals shall meet the following requirements:

- 1.** Shall be low sudsing.
- 2.** Shall be safe for use in an enclosed environment.
- 3.** Shall be compatible with onboard water reclamation and/or waste disposal systems.
- 4.** Shall not stain or discolor the surface being cleaned.
- 5.** Shall be in an easy-to-use, controllable content container.

**6.** Shall not produce a foul, unpleasant, lingering odor.

**c.** Illumination - Adequate illumination for visual inspection and cleaning of both internal and external housekeeping features.

(Refer to Paragraph 8.13.3, Lighting Design Requirements, for specific illumination requirements.)

**d.** Wipes - The following types of wipes for use in general housekeeping and personal hygiene shall be provided:

**1.** Dry wipes - Utility tissue used as toilet tissue and for compartment and equipment cleaning.

**2.** Wet wipes - Saturated tissues to be used for personal cleansing.

**3.** Biocide wipes - Biocide-saturated pads used for disinfecting food spills, waste management systems, etc.

**4.** Reusable wipes - Utility handwipes that can be impregnated or dampened with premixed evaporative detergent/biocidal solutions or with water.

**5.** Detergent wipes - Detergent saturated tissues for interior cleaning tasks, food spills, etc.

**6.** Utensil Cleansing Wipes - Cleaning agent and sanitizers impregnated into tissues for post-meal utensil cleansing and sanitizing.

**e.** Cleaning Implements - Provide means for dislodging and collecting dirt and debris from surfaces, cracks, and crevices.

**f.** One-Handed Operation - Cleaning equipment and supplies shall be designed for one-handed operation or use.

**g.** Housekeeping Cleansing Agents - A non-biocidal cleansing agent or agents, shall be provided for general purpose surface cleansing in which specific biological control is not required. A biocidal cleansing agent or agents shall be provided for clean-up of biological spills and biologically contaminated surfaces.

**h.** Biofilm Control - Means shall be provided to control the formation and growth of biofilm on the inside surfaces of all fluid lines and pipes so as not to degrade the mission.

### **13.2.3.3 Vacuum Cleaning Design Requirements**

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An onboard vacuum cleaner shall be provided. It shall meet the following requirements:

**a.** Suction - The system shall provide adequate suction capability for the collection and retention of both wet and dry particulate matter and of liquids.

**b.** Noise Level - The system shall have noise levels compatible with Paragraph 5.4.3.2.

(Refer to Paragraph 5.4.3.2, Noise Exposure Requirements, for noise exposure design requirements.)

**c.** Attachments - The system shall provide an assortment of attachments which conform to the various surfaces that need to be cleaned (e.g., flat surfaces, filters, cracks, crevices, corners, etc.)

**d.** Disposable Bags - The system shall provide disposable bags:

**1.** Suitable for containing both dry and liquid wastes.

- 2. Compatible for compaction in a trash compactor.
- 3. Designed for long life, i.e., minimize frequency of replacement.
- e. Lighting - Sufficient lighting shall be provided to illuminate the area to be cleaned.
- f. Nonpropulsive - Propulsive characteristics and self-generated torques of the system shall be compensated for in the design.

### **13.2.3.4 Air Filter Design Requirements**

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Filters used in the air revitalization system and air-cooled equipment collect airborne debris and, therefore, become an indirect but important element of the housekeeping system. Equipment filters shall be designed to provide the following housekeeping features:

- a. Access - Air filters (grids, screens, filter surfaces) shall be readily accessible for cleaning and replacement without disturbance of collected material.
- b. Configuration - Nondisposable air filters shall be configured to allow them to be cleaned by a vacuum cleaner attachment.

(Refer to Paragraph 13.2.3.1, General Housekeeping Design Requirements, item g, for other filter design requirements.)

- c. Filter Condition - The design of the air filter shall incorporate the means to inform the crew of the overall condition of the filter (e.g., visual feedback, AP sensor).

### **13.2.4 Example Housekeeping Design Solutions**

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The following are examples of housekeeping items that have been used on the Shuttle orbiter (refer to Paragraph 13.2.2 for a discussion of the positive and negative features of these items):

- a. Cleanser - A liquid biocidal detergent formulation in a squeeze-bottle-type container, with a built-in bladder, dispensing valve, and nozzle. The cleanser is sprayed on the surface that is to be cleaned and is then wiped clean with dry wipes. This cleanser is used to clean the urinal and toilet seat, walls, and floor.
- b. Dry Wipes - Dry wipes are packaged in dispensers and are used for all general purpose cleaning jobs.
- c. Wet Wipes - Wet wipes have been extensively used for general purpose cleaning. They have also been used for personal hygiene (hand cleaning, bathing, etc.)
- d. Disposable Gloves - Plastic disposable gloves are provided for use when a crewmember is using the biocidal cleanser, which would otherwise stain their hands.
- e. Vacuum Cleaner - A portable vacuum cleaner that can be hand carried is provided for general housekeeping and for cleaning air filters.

## **13.3 INVENTORY CONTROL**

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### 13.3.1 Introduction

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This section provides the considerations and requirements for onboard inventory control systems design.

The inventory control function is one of the primary elements of onboard information management (refer to Paragraph 13.4, Information Management). Inventory control is directly related to the stowage design considerations and requirements addressed in Paragraph 10.12 (Stowage). Also, refer to the labeling and coding requirements given in Paragraph 9.5 (Labeling and Coding).

### 13.3.2 Inventory Control Design Considerations

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One of the most difficult areas of flight data management for manned spaceflights has been the creation and maintenance of the on-board inventory management system that keeps track of inventory such as crew equipment, consumables, food, experimental materials, etc., and where these items are located. Of necessity, the stowage list and the launch, on-orbit, and return stowage locations constantly change. This requires frequent, late, and significant revisions to stowage documentation, which is the crew's overall reference on loose item location, quantity, and transfers. Every change to the inventory and stowage location impacts other documentation. For example, checklists that contain reference to stowage data must be updated if the location of an item is changed.

Several instances arose in Skylab where an item became lost and the ground had to institute a search through transcripts and by questioning the crew about last usage or sighting.

A significant problem associated with inventory control which was experienced in the Skylab was the nomenclature used in referring to the various hardware, consumables, stowage locations, etc. Many names existed for a single item. This lack of standardization resulted in confusion, ambiguity, and lost time when communicating among various users.

Crewmember time is a most costly resource, so it is necessary to minimize the time required for the overhead involved in the inventory control function. A reliable, easy-to-use inventory control system will, therefore, be a cost effective investment. Advances in the state-of-the-art of onboard computers, data storage devices, software, bar coding systems, and communications data links make a computerized inventory control data management system feasible and desirable.

The inventory control system must be capable of providing both on-line and hardcopy reports. On-line reports are used for a) display of information in connection with making updates to the database and b) real-time display of information for crew activity planning and flight control activities. Hardcopy reports are used for a) a hand-carried reference when verifying stowage locations, quantities, etc., and b) for a markup media for planning.

The inventory control database should include, as a minimum, the following data elements:

- a. Item Number - The basic control number by which each item is identified in the database.
- b. Item Name - The standard name used to describe the item.
- c. Item Functional Designation - An easy-to-learn code that indicates the functional usage of the item.
- d. Unit Weight - The weight in kilograms (pounds) of one unit of the item.
- e. Unit Volume - The volume in cubic centimeters (cubic inches) of the envelope space required to stow a unit item.
- f. Length - The length in centimeters (inches) of the envelope space necessary to contain the item.

- g. Width** - The width in centimeters (inches) of the envelope space necessary to contain the item.
- h. Height** - The height in centimeters (inches) of the envelope space necessary to contain the item.
- i. Stowage Location** - The stowage location code of the stowed item during each mission phase (e.g., launch, on-orbit, return).
- j. Quantity Stowed in Each Location** - The quantity of items stowed in each stowage location during each mission phase.
- k. Total Quantity** - The total quantity of each item during each mission phase.
- l. From Location** - The stowage location code from which stowed items are transferred during in-flight phases of the mission.
- m. To Location** - The stowage location code to which stowed items are transferred during in-flight phases of the mission.
- n. Quantity Transferred** - The quantity of items transferred (or scheduled to be transferred) from one location to another during in-flight phases of the mission.
- o. Performance History** - A provision for recording crew comments pertinent to the condition and performance of the item during the in-flight phases of the mission.
- p. Stowage Location Maps** - Stowage location illustrations are required to the extent that the difficulty in locating or transferring an item necessitates additional data to support the crew procedures.
- q. Life Remaining** - The shelf life remaining for consumables and the operating life remaining for operating hardware.
- r. Limit Quantity** - The quantity of items/consumables below which mission operations may be constrained.
- s. Crew Identification** - Indicate the name of the crewmember on personal items.

It is also necessary to distinguish the differences between the kinds of inventory control information required by the ground operations versus that of the onboard crew. Some of the onboard inventory control data should be capable of being communicated to the ground without onboard crew involvement.

### **13.3.3 Inventory Control Design Requirements**

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This section provides the man-system interface design requirements for computerized data management for onboard inventory control. General, database, and report requirements are given.

#### **13.3.3.1 General Inventory Control Design Requirements**

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A computerized data management system for the onboard inventory system is required. This system shall provide the following capabilities:

- a. Ground Compatibility** - the onboard and ground inventory data formats shall be identical.

**b. Telemetry** - The inventory management system shall interface with the telemetry system for real-time uplink and downlink.

**c. Automatic Updating** - The system shall provide the capability to automatically revise the inventory control database and other data references affected by stowage/inventory changes.

**d. Standard Procedures** - The system shall provide a user/computer procedural interface that is standardized with other data management functions.

(Refer to the Section 9.6.3, User/Computer Interaction Design Requirements, for specific design requirements for the user/computer interface.)

**e. Standard Nomenclature** - The nomenclature used to refer to the items tracked by the inventory management system shall be identical to, and standardized with, that used on design drawings, training hardware, checklists, and procedures, labels, etc.

**f. Cross Indexing** - The information in the database shall be indexed with many cross reference categories to facilitate ease of data retrieval.

**g. Minimize Inventory Control Crew Time** - The inventory control system shall be designed to minimize the amount of crew time required for the inventory control functions. A design goal shall be that the inventory control function shall require no direct crew input, but rather shall automatically track items and update the database.

### **13.3.3.2 Inventory Control Reports Requirements**

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The inventory management system shall be capable of providing both on-line and hardcopy reports. At a minimum, the following types of reports shall be provided:

**a. Item Status** - Display the location(s) for an item that is selected by item number or item name. This report shall include the quantity of the item at each location.

**b. Transfer Status** - For an item selected by name or by number or for all items, provide a report that displays the From Location, the To Location, and the quantity to be transferred.

**c. Location Status** - Display items (by item number and item name) stowed in a specified stowage location. Quantity of each item in the specified location shall also be provided.

**d. Limit Warning Report** - Provide an alert message that indicates when quantities of consumables, or items, fall below a predetermined safe limit.

## **13.4 INFORMATION MANAGEMENT**

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### **13.4.1 Introduction**

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This section provides the design considerations, requirements, and examples for onboard information management. Information management refers to the storage, transmission, manipulation, and display of information. An information management system therefore includes all hardware and software to support these functions.

## **13.4.2 Information Management Design Considerations**

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Modern manned spacecraft presently use a combination of hardcopy documentation and electronic media for providing the onboard crew with the information they require for planning, operations, and maintenance activities.

Accessing data from either computer data records or from hardcopy documents is a significant time-consuming, and therefore costly, problem for the crew. Computer relational databases, video disks, and artificial intelligence systems should be considered for storing, retrieving and interpreting the large amounts of data.

Flight information that should be maintained in the onboard computers includes resource allocation status (e.g., power, thermal); subsystem performance trend data, maintenance data (e.g., schematics, procedures, reference data); medical imagery (e.g., X-rays); crewmember medical data, payload data, and inventory control records.

(Refer to Paragraph 13.3, Inventory Control, for design considerations and requirements.)

Some documents, maps, checklist cards, etc. are hardcopy items that may still be required even though electronic information management systems are used. The use of these hardcopy items creates a need for writing surfaces and stowage for the document's associated office supplies.

Typical office supplies include notebooks, pens, pencils, page clips, tape, and rubber bands. The pens and pencils have Velcro patches attached to them so that they can be restrained on the writing surface or other adjacent surface. In microgravity, document pages will not lay down, so clips are used to keep the document opened to a selected page. Documents are restrained to surfaces using elastic bungee cords or other restraint devices such as Velcro patches attached to the backs of the page clips that interface with Velcro patches located on vehicle surfaces.

A design goal should be to eliminate as much hardcopy data, management material, and associated office supplies as possible.

## **13.4.3 Information Management Design Requirements**

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### **13.4.3.1 General Information Management Design Requirements**

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The following general requirements apply to both hardcopy or electronic information management systems:

**a. Minimum Onboard Information** - At a minimum the following information shall be accessible onboard:

- 1. System Maintenance and Troubleshooting Procedures**
- 2. Trend data Acquisition and Analysis**
- 3. Consumable Status**
- 4. Payload Data Collection**
- 5. Experiment Procedures**
- 6. Repair and Replacement Information**

## 7. Medical History

## 8. Inventory Control Data.

(Refer to Paragraph 13.3.3, Inventory Control Design Requirements.)

**b. Information Management Facilities** - Information management facilities shall be provided in the spacecraft for stowing, receiving, displaying, processing, and updating mission data.

**c. Information Display Orientation** - The information display provisions shall allow orientation of the data to the optimum position for use while performing the mission tasks that use the information.

**d. Hands Free Use of Information** - The information display provisions shall leave the crewmember's hands free once the data has been positioned.

**e. Data File Organization** - Means shall be provided to stow mission data in organized, segmented data files in which individual data records can be readily obtained.

**f. Flight Data Hardcopy** - As a minimum, hardcopy file data shall be maintained on board for all procedures for emergency operations of the spacecraft, continued crew safety, rescue, or escape.

### 13.4.3.2 Hardcopy Information Management Design Requirements

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The following requirements pertain to hardcopy information media and associated hardcopy equipment and supplies:

#### **a. Restraints :**

**1. Equipment restraints** - Means shall be provided for restraining documents, loose sheets of paper, writing implements, and supplies required for documentation update (tape, scissors, etc.) at each information management workstation.

(Refer to Paragraph 11.7.3.3, Equipment Restraints Design Requirements, for specific requirements.)

**2. Personnel restraints** - Means shall be provided to restrain the crewmembers at the various workstations in a manner that leaves both hands free for documentation update and recording.

(Refer to Paragraph 9.2.4.2.3, Workstation Restraints and Mobility Aids Design Requirements, for specific requirements.)

**3. Document restraints** - Means shall be provided to hold documents open to specific pages.

**b. Writing/Working Surface** - Fixed and portable writing/working surfaces shall be provided.

**c. Writing Instruments and Supplies** - Writing instruments and supplies required for documentation update (e.g., scissors and tape) shall be provided.

**d. Stowage of Writing Instruments, Supplies, and Documents** - Consolidated stowage shall be provided for writing instruments, supplies, and documents in locations that are accessible to a restrained crewmember.

(Refer to Paragraph 10.12.3, Stowage Facility Design Requirements, for specific requirements.)

e. Illumination - Adequate illumination shall be provided for each workstation where hand documentation normally will be prepared.

(Refer to Paragraph 8.13.3, Lighting Design Requirements.)

f. Onboard Printer/Copier - Capability for onboard preparation and duplication of hardcopy documentation shall be provided.

### **13.4.3.3 Electronic Information Management Design Requirements**

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Information located in electronic data storage shall be accessible using multiple access categories (e.g. multiple keywords).

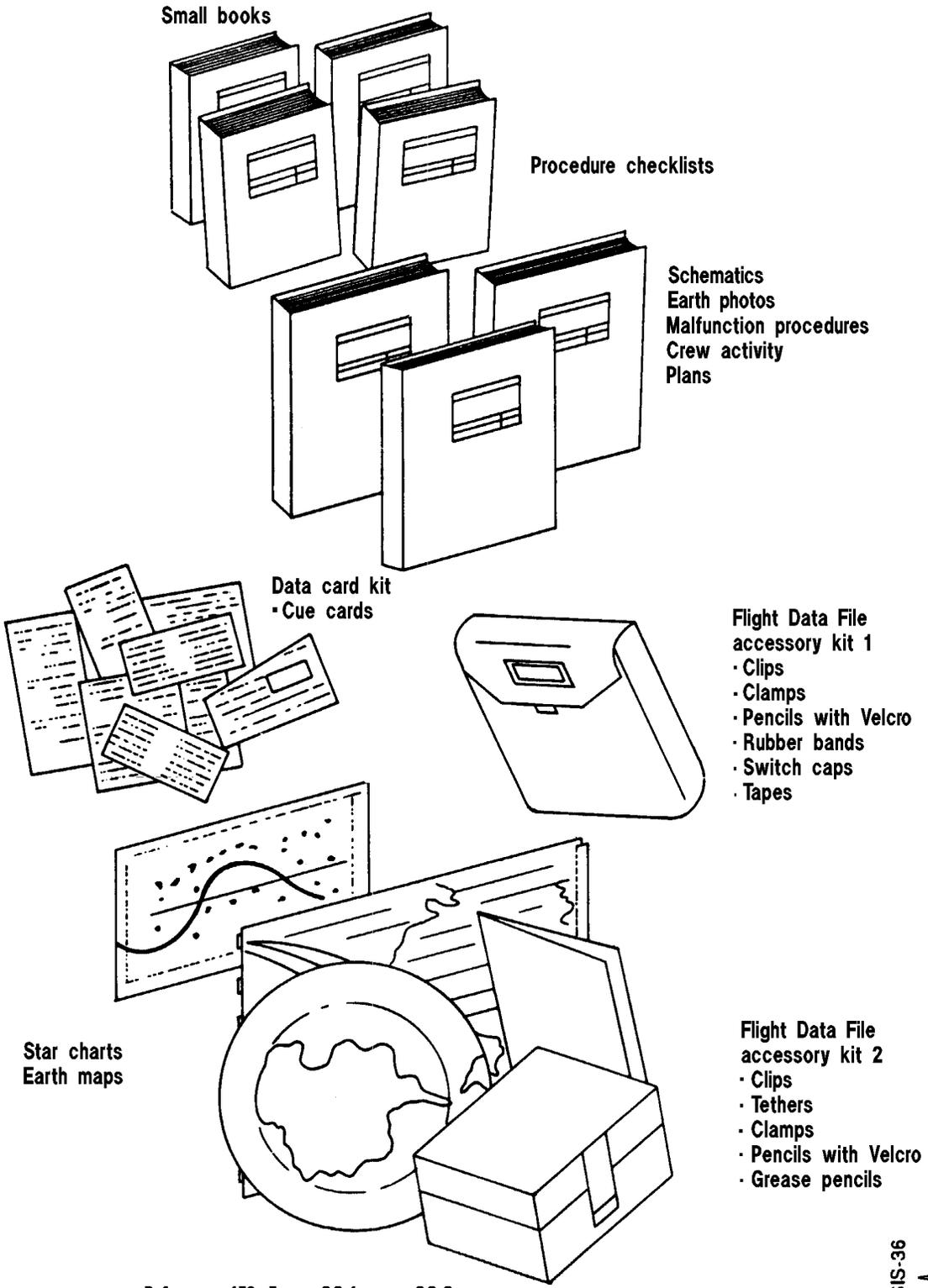
(Refer to Paragraph 9.6.3.1.2, User/Computer Interaction Design Requirements, for specific electronic information interface design considerations and requirements.)

### **13.4.4 Example Information Management Design Solutions**

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The Shuttle Orbiter's Flight Data File (FDF) is the total onboard complement of flight operations documentation readily available to crewmembers. It is composed of, but not limited to, the items shown in Figure 13.4.4-1. The FDF is stowed in both fixed and portable containers and in cloth bags in such a manner as to be readily available to the crew on the flight deck and middeck and during airlock/cargo bay EVA and flight operations.

**Figure 13.4.4-1 Flight Data File (FDF) Items (Typical)**



Small books

Procedure checklists

Schematics  
 Earth photos  
 Malfunction procedures  
 Crew activity  
 Plans

Data card kit  
 - Cue cards

Flight Data File  
 accessory kit 1  
 - Clips  
 - Clamps  
 - Pencils with Velcro  
 - Rubber bands  
 - Switch caps  
 - Tapes

Star charts  
 Earth maps

Flight Data File  
 accessory kit 2  
 - Clips  
 - Tethers  
 - Clamps  
 - Pencils with Velcro  
 - Grease pencils

Reference: 150, Figure 3.2-1, page 3.2-2

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**Figure 13.4.4-1 Flight Data File (FDF) Items (Typical)**