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COINS: A Composites Information Database System

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Abstract

An automated data abstraction form (ADAF) has been developed to collect information on advanced fabrication processes and their related costs. The information will be collected for all components being fabricated as part of the ACT program and included in a COmposites INformation System (COINS) database. The aim of the COINS development effort is to provide future airframe preliminary design and fabrication teams with a tool through which production cost can become a deterministic variable in the design optimization process. The effort was initiated by the Structures Technology Program Office (STPO) of the NASA Langley Research Center to implement the recommendations of a working group comprised of representatives from the commercial airframe companies. The principal working group recommendation was to re-institute collection of composite part fabrication data in a format similar to the DoD/NASA Structural Composites Fabrication Guide. The fabrication information collection form has been automated with current user friendly computer technology. This work in progress paper describes the new automated form and features that make the form easy to use by of an aircraft structural design-manufacturing team.

Introduction

The U.S. transport aircraft industry has over two decades of experience in manufacturing composite secondary structures. These applications, including elevators, rudders, spoilers, landing gear doors, fairings, etc., use approximately 400,000 pounds of composite materials per year.

Despite the fact that composite materials offer design advantages in terms of weight, corrosion resistance and fatigue life, their application in commercial aircraft has been limited relative to metals. A modest leap forward will occur when the new Boeing 777 is manufactured with carbon fiber horizontal and vertical stabilizers. High cost and the uncertainty in the cost prediction for composite structures are the main factors holding back more extensive use of these materials in commercial aircraft

One goal of the NASA Advanced Composites Technology (ACT) program is to have several airframe manufacturers design and fabricate composite structures with superior performance compared to equivalent aluminum structures and significantly lower in cost than that of earlier composite concepts. New and automated manufacturing processes will be used. The fabrication labor hours and costs involved will be tracked and reported to NASA. For a number of past DoD and NASA composite structures development programs, such information was submitted to the Air Force for inclusion in the DoD/NASA Advanced Composites Fabrication Guide using the "Fabrication Guide Data Abstraction Form" or "DAF", Reference 1. The NASA/DoD program to collect fabrication cost information ended in 1983. A working group of commercial airframe industry representatives recommended that NASA collect information on the actual costs of fabricating composite components being made as part of the ACT program. This information could be used to compare and evaluate various composite fabrication techniques and provide a technical database for 21st century aircraft structures.

Coupling fabrication cost information with an improved cost estimating model for composites (Reference 2) is the first step toward providing future concurrent engineering teams with a tool that can be used to include cost as a design variable during the preliminary design stage. Such a tool will have exceptional value since industry experience shows that 70% of airplane fabrication costs are fixed when the design is frozen.

The current status of the development of the automated data acquisition form (ADAF) for collection of fabrication cost information will be described in this paper. The fabrication cost information will become a part of the COmposites INformation System (COINS).

COINS and Automated Data Abstraction Form Development

The COINS database will be implemented with a commercially available relational database software package. The software selected is Informix-OnLine ® with the WINGZ™ spreadsheet as an interface. This software was selected because it is used, supported and accepted in the commercial environment. Furthermore, the interface is user friendly and the database takes advantage of emerging technology for storing and retrieving images and text files as well as data fields. It also has a demonstrated capability to operate with MS-DOS®, Macintosh®, UNIX®, and other common operating systems.

The recommendations of the commercial airframe industry representatives from two workshops organized by STPO were reported in Reference 3. A third workshop was held in January 1991 and was devoted to a detailed evaluation of the DAF referred to above. As a result of this workshop, the form was modified to reflect current composites fabrication technology and the recommendations were incorporated in the new automated data acquisition form (ADAF). The input fields included in the new form are listed in Table 1.

The ADAF will be used to provide input data for COINS and has been designed to interface with a database update module. Initially, ADAF information will be submitted to NASA on a floppy disk where it will be checked by a software module for format and for "sanity" or "reasonableness" of the data. The data will then be transferred to the COINS database by AS&M personnel. Selected data from the DoD/NASA Advanced Composites Fabrication Guide will also be transferred to COINS to provide direct comparison of current data with that from past programs.

At present, the data base will reside on a Silicon Graphics IRIS™ workstation (operating under the UNIX operating system). The IRIS is connected to the NASA Larcnet. In the future, ACT contractors will be given access to this machine for submitting data by electronic mail. The transfer of ADAF data into the COINS database will still be performed by AS&M personnel. Users will have read only access to the database to avoid inadvertent changes or contamination of the data. The data will be accessible through user friendly database search procedures that can be built up with menu driven functions or that respond to direct user input queries such as "retrieve material types and labor hours for wing ribs manufactured with autoclaves". The retrieval modules will also interface with the WINGZ spreadsheet whose color graphics capabilities provide the user with a variety of form, graph and chart layouts. A user manual win be provided by AS&M for the ADAF and retrieval software.

The ADAF and the data retrieval procedures via WINGZ is almost identical in appearance on MS-DOS or Macintosh microcomputers. Similarly, they are compatible with UNIX environment workstations. This feature should be attractive for interfacing with the CAD/CAM capability available in the industry. Users will be computer platform independent and only one user manual will be required no matter what computer is used to host the WINGZ spreadsheet package. The only requirement is that users will have to purchase WINGZ software for the operating system they choose to use. WINGZ is available for the MS-DOS, Macintosh or UNIX operating systems, the WINGZ software has also been ported to some other operating systems.

The ADAF form is expected to require input from more than one member of a preliminary design/fabrication engineering team. The form is arranged so that each input screen/page can be completed by an appropriate member of the team. The software is intelligent enough to prompt the user for only the required input choices on the basis of previously entered input. A Glossary function that explains the fabrication terms and processes will always be available to the user via a pull down menu. Figure 1 shows a block diagram of the screen pages in the ADAF.

Following an opening screen, the user is presented with the general information screens/forms shown in Figures 2 and 3. These screen/forms collect information about the part and the aircraft in which the structural part or assembly will be used. A typical fabrication data input screen is shown in Figure 4. The descriptors in the upper right-hand corner of each screen suggest which team member might fill out that page of the form.

The following control features (see Figure 3a) are available for each ADAF screen:

(1) Pull down menus.

(2) User activated hidden buttons.

(3) Paging buttons in the lower right hand corner labeled HOME, NEXT, BACK, and ACCEPT.

The pull down menus provide overall WINGZ software control that allow the user to enter or exit the ADAF and access the Help information available. The set-up should be familiar to users of window-type software on workstations and micro computers.

Hidden buttons are used to provide user friendly input assistance. The required input fields on the ADAF screens are displayed in blue (underlined in the figures included in this paper) or in red (not underlined in the figures). There are hidden buttons located under the blue input text (the text itself may be thought of as the button) are activated when the user clicks the computer mouse button on any area of this text. For example if the button below *Aircraft Type* was activated, the options displayed in Figure 3b would appear. The user must make selections regarding the aircraft classification by positioning the mouse cross-hairs on the selection squares and clicking. This selects that text and records it as input for the active field.

The red input prompt text (denoted by the text that is not underlined on the figure) requires direct user input from the keyboard into the dashed prompt box that appears adjacent to this text. The user types text into the box and presses the enter/return key to terminate and record the input. The user may also use the arrow keys to move between such input boxes.

The paging buttons in the lower right hand side have the following functions and allow the user to move to different screens of the ADAF:

NEXT — Advances the user to the next screen without saving the input entered on the current screen/page. This button allows users to skip input screens that may be more appropriately addressed by another team member.

ACCEPT Functions like the NEXT button described above except that the input for the current screen/page is saved. This button should be used to advance screens after completing the appropriate input.

BACK Functions like the NEXT button; skips or positions the user to the previous screen without saving (or altering) the input.

HOME Returns the user to the first screen/page.

The ADAF is being designed to serve the needs of the preliminary design/fabrication teams in industry. The DoD/NASA DAF only required fabrication data input. Future needs of the airframe industry may best be served if design information is collected simultaneously. Screens will be proposed for including design related information to the ADAF to expand it beyond the original DAF. These design screens will prompt the user for information such as loading type, design strain level, etc..

Summary Remarks

The work in progress status of the Advanced Composites Technology program Composites Information System (COINS) effort has been described. An automated data acquisition form (ADAF), based on the DoD/NASA Advanced Composites Fabrication Guide data abstraction form, has been developed. The form is available for use on Macintosh, MS-DOS and UNIX systems. A test version of the ADAF has been distributed to ACT contractors and is currently being evaluated. Evaluators comments and recommendations will be incorporated into a production version of the ADAF that will be made available for ACT program distribution.

References

(1) Meade L. E., DoD/NASA Structural Composites Fabrication Guide-3rd Edition, Vol 1-2, Air Force Wright Aeronautical Laboratories, 1982.

(2) Freeman W. T., Ilcewicz L., Swanson G., and Gutowski T., Designer's Unified Cost Model, Proc. 9th DoD/NASA/FAA Conf. Fibrous Composites in Structural Design, Lake Tahoe, NV, Nov. 1991.

(3) Freeman W. T., Vosteen L. F., and Siddiqi S., A Unified Approach for Composite Cost Reporting and Prediction in the ACT Program, Proc. of the 1st NASA ACT Meeting, Seattle, Wash., Nov. 1990.

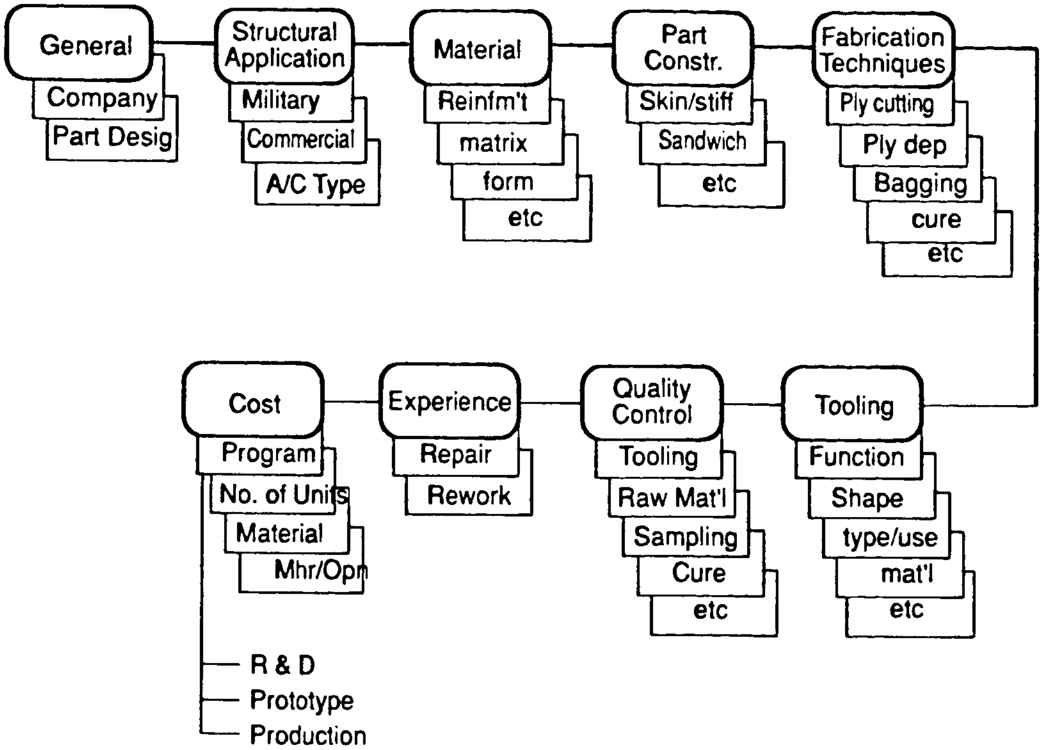


Figure 1. A Block Diagram of the ADAF.

1.GENERAL

General

Company: STPO Inc

Division: Structural Design

Recorder*: Designer A C (Last Name, - First Initial) — **Aircraft** (Org./Dept.) — **804-827-8000** (Phone Number)

Fabrication Date: 08-23-91 (Month/Day/Year)

***If information is provided by more than one person, show name of principal point of contact>**

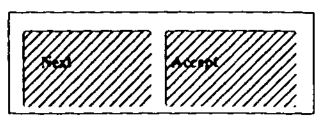
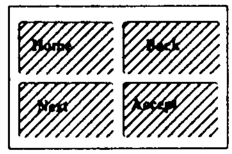


Figure 2. The ADAF General Information Screen.

2.AIRCRAFT APPLICATION

Designer

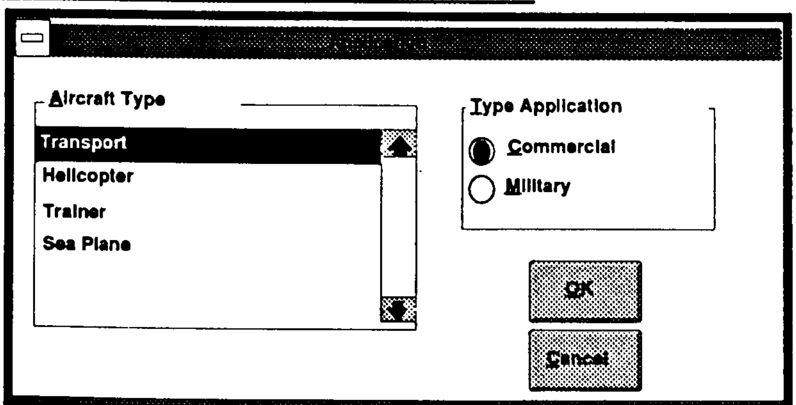
Application: Commercial
Aircraft Type: Transport
Role: utility
PowerPlant: Turbofan
Structural Level: Primary
Vehicle Model No.: C-11-30D
Part Number or Description: W123/45-P(C-11-30D) Wing rib
List Dimensions & Weight: 6ft chord, 2ft thick, 20 lb
Quantity per assembly (of this part): 10
Next Assembly: wing inboard section 3
Maximum Service Temperature: 200 deg. f
Total Accumulated Test Hours to Date: 255 hrs
Type of Test: Destructive
Equivalent Life Times: 2
Total Accum. Flight Hrs. to Date: 50 hrs



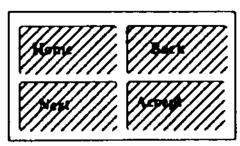
(a) The ADAF Aircraft Information Screen.

2.AIRCRAFT APPLICATION

Designer



Total Accumulated Test Hours to Date: 255.00
Type of Test: Destructive
Equivalent Life Times: 0.01
Total Accum. Flight Hrs. to Date: 50.00



(b) The ADAF Aircraft Information Screen with the Dialog Box Display.

Figure 3. Example screens for "Aircraft Application".

7.FABRICATION TECHNIQUES

Fabricator

Ply Deposition:	RTM	
Deposition Mode:	Semiautomatic	
Deposition Method:	Ply-By-Ply In On Tool	
Ply Cutting:	Water Jet	
Cutting Mode:	Manual	
Compaction:	Pressure	
Bag Material:	Elastomeric	
Seal:	Permanent	
Bleeder:	Fiberglass Cloth	
Curing Consolidation:	Self -Contained	
Atmosphere:	Air Vented Bag	
Max Cure Temp.:	350	(degrees Farenheit)
Max Cure Pressure:	200	psi
Total Cure Time:	20	(hours)
Max. Heating Rate:	10	(degrees Farenheit/min.)
Post Cure Heat Treat:	10	(degrees Farenheit/min.)
Heat Treat. Time:	10	(hours)

Cure Profile

Home Back
Next Accept

Figure 4. The ADAF Fabrication Information Screen.

Table 1. Data fields included in automated data abstraction form.

GENERAL
1. Company
2. Division
3. Recorder
4. Date Recorded

APPLICATION
5. Commercial/Military
6. Aircraft Type
7. A/C Role
8. Power Plant
9. Structural Level
10. Vehicle Model No.
11. Part Number or description
12. Dimensions
13. Weight
14. Quantity per Assy (of this part)
15. Next Assembly
16. Maximum Service Temperature,°F
17. Total Cum Test Hours to Date
18. Type of Test
19. Equivalent Life Times
20. Total Cum. Flight hrs. to Date

MATERIAL
21. Matrix
22. Reinforcement
23. Reinforcement Type
24. Product Form
25. Material Type
26. Width, in.
27. Length, in.
28. Thickness, in.
29. Discontinuous fiber type
30. Fiber Diameter, mils
31. Tow Diameter, mils
32. Tow fiber count
33. Supplier Code No.
34. Specifications (if applicable)

TOOLING
Fabrication Tooling
35. Function
36. Shape
37. Surface
38. Surface Support
39. Type
40. Tool Surface Material
41. Elastomer type (if used)
42. Supplier (if applicable)
43. Designation (Name or Code No.)
44. Fabrication Technique
45. Life Expectancy, parts per tool
46. Surface Preparation
47. Maintenance Experience

Assembly Tooling
48. Assembly Parts
49. Next Assembly
50. Function
51. If Bonded Fixture . . .
52. Adhesive Tradename & No.
53. Braze Alloy Name & No., if used
54. Fastener Tradename & No.
55. Number of fasteners
56. High Temperature Exposure
57. (If Yes) Type
58. Max. Temperature, °F.
59. Material
60. Life Expectancy, units
61. Maintenance Experience

PART CONSTRUCTION
62. Shape
63. Construction Method
64. Substructure
65. Core
66. Stitching
67. Molding method
68. Leading Edge Protection
69. Leading Edge/Airfoil Bond
70. X-Section Shape

Ply Information
71. Max. Number of Plies
72. Min. Number of Plies
73. Ply Layup ___0°___45°___90°
74. Other Orientation (specify)

Weights
75. Raw Material Purch for Part, pd
76. Total Part (incl. noncomp.), pd
77. Noncomposite Part, pd
78. Trimmed Material, pd
79. Test Material, pd
80. Completed Part, pd (comp. only)
81. Assembly, pd

Dimensions
82. Max. Width, in.
83. Max. Thickness, in.
84. Max. Length, in.
85. Wetted Area, sq in
86. Outside Diameter, in.
87. Wall Thickness, in.
88. Taper Ratio, in./inch

FABRICATION TECHNIQUES
89. Ply Deposition
90. Deposition Mode
91. Deposition Method
92. Ply Cutting
93. Compaction
94. Bag Material
95. Seal
96. Bleeder
97. Curing /Consolidation
98. Max. Cure Temp., °F
99. Max. Cure Pressure, psi
100. Total Curing Time, hrs.
101. Max. Heating Rate, °F/min.
102. Atmosphere
103. Post Cure/Heat Treat, °F
104. Post cure time, hrs.
105. Cure Profile

Table 1. (concluded)

FABRICATION TECHNIQUES (cont.)

Secondary Fabrication Operations

106. Final Sizing/Mat'l Removal
107. Holes/Penetrations
108. Cutting Tool Material

Surface Preparation (for Bonding)

109. Metal
110. Resin Matrix
111. Bonding type
112. Adhesive bonded and/or fastened?
113. Adhesive Tradename & No.
114. Fastener Tradename & No.
115. No. of Fasteners
116. Fastener Pitch
117. Braze Alloy Name & No., if used

Finishing Operation

118. Surface Treatment
119. Painting
120. Erosion Protection
121. Lightning Protection

QUALITY CONROL

122. Primary Tool/Part Process Qual.
123. Periodic Inspection
124. Inspection Frequency

Part Raw Material Inspection

125. Initial Inspection
126. Reinspection During Production

Sampling Technique

127. In process (Fab.) Controls
128. Orientation and Number of Plies
129. Inserts/Attachments/Tag Ends
130. Test Panels
131. Leak Check

Curing Consolidation

132. Continuous/intermittent Record
133. Dielectrometry

Finished Part Inspection

134. Visual
135. Ultrasonic
136. Destructive
137. Acoustic Emission
138. Radiographic
139. Infrared
140. Microwave
141. Phototropic
142. Proof Loading
143. Other
144. Acceptance Rate, %

COST

145. Cost basis
146. Development Status
147. Production Rate, units/month
148. Total Number Produced to Date
149. Total Number Planned
150. Time Span of Manufacture
151. Price of Part Raw Material $/Pound
152. Yr. Purchased
153. Price of Purchased Components $/Part

Direct Fabrication Labor (manhours/unit) by operation

154. Tool Preparation
155. Composite Orientation
156. Pattern Cutting
157. Layup/Detail Installation
158. Honeycomb Preparation
159. Instrumentation
160. Bagging/Tool Closure
161. Cure/Consolidation
162. Post Cure
163. Part Removal/Cleanup
164. Machining/Trimming/Drilling
165. Finishing
166. Assembly
167. Total Fabrication Hours

Direct Assy Labor (MH/unit) by operation

168. Fixture Setup
169. Detail Installation
170. Bonding/Fastening
171. Hole Preparation
172. Shimming
173. Instrumentation
174. Cure
175. Post Cure
176. Part Removal/Cleanup
177. Machining/Trimming/Drilling
178. Total Assembly manhours

Tooling Costs

179. Material, $
180. Design Labor, manhours
181. Fabrication Labor, manhours
182. Inspection Time, manhours

Assembly Costs

183. Price of Purch. Components, $/Assy
184. Learning Curve Projected, %
185. Learning Curve Actual, %

Fixture

186. Material, $
187. Design Labor, manhours
188. Fabrication Labor, manhours
189. Inspection Time, manhours

EXPERIENCE

190. Repair Documentation Reference
191. Is Mil-P-9400 used?
192. Problems/Rework
193. Other References
194. User Recommendations
195. Learning Curve Projected, %
196. Learning Curve Actual, %