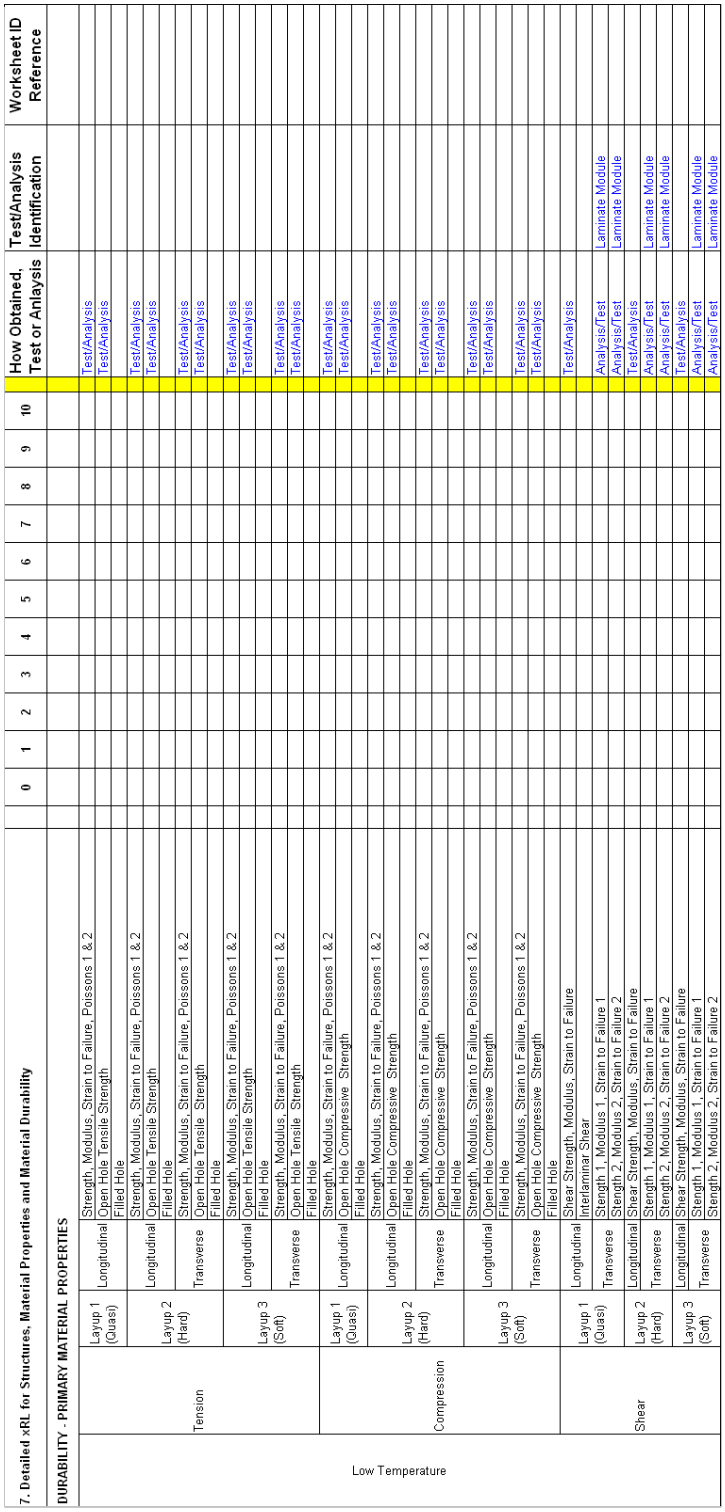
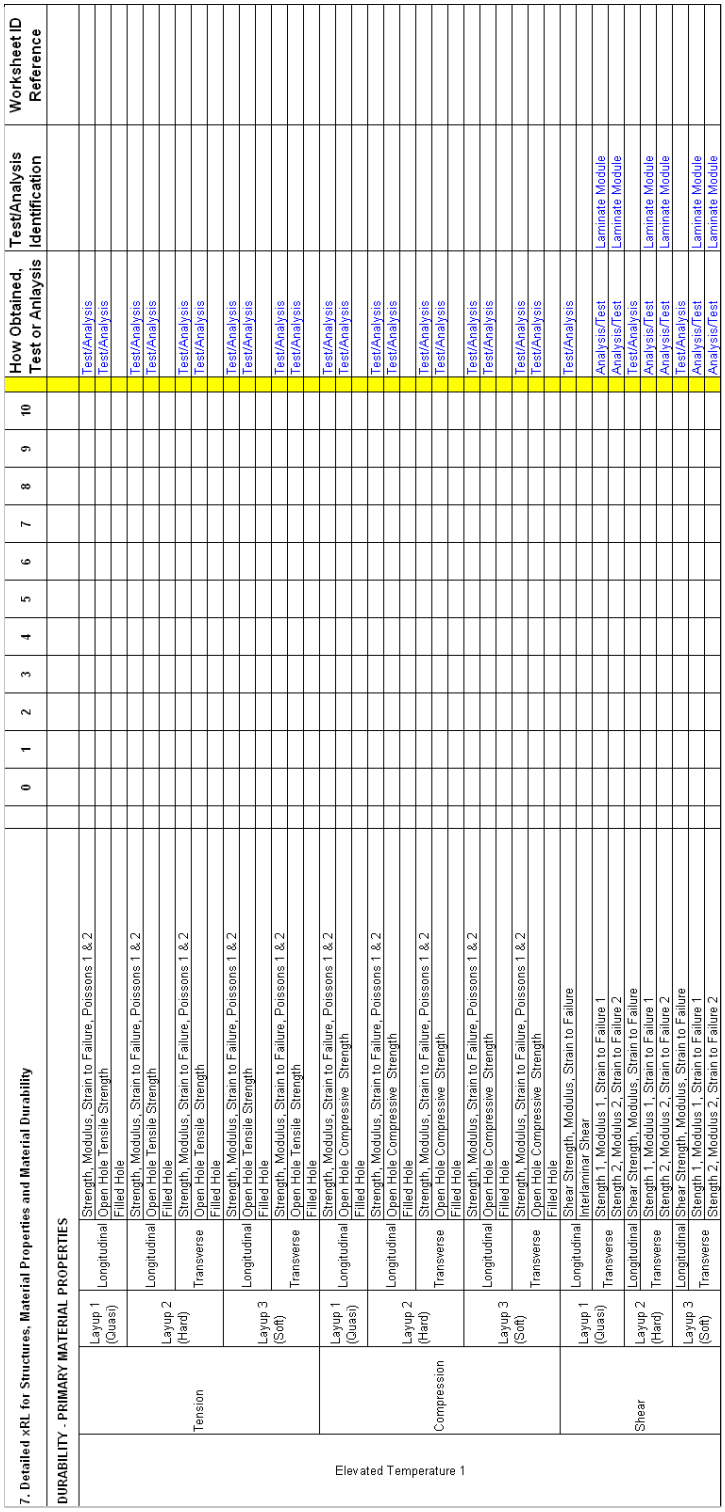


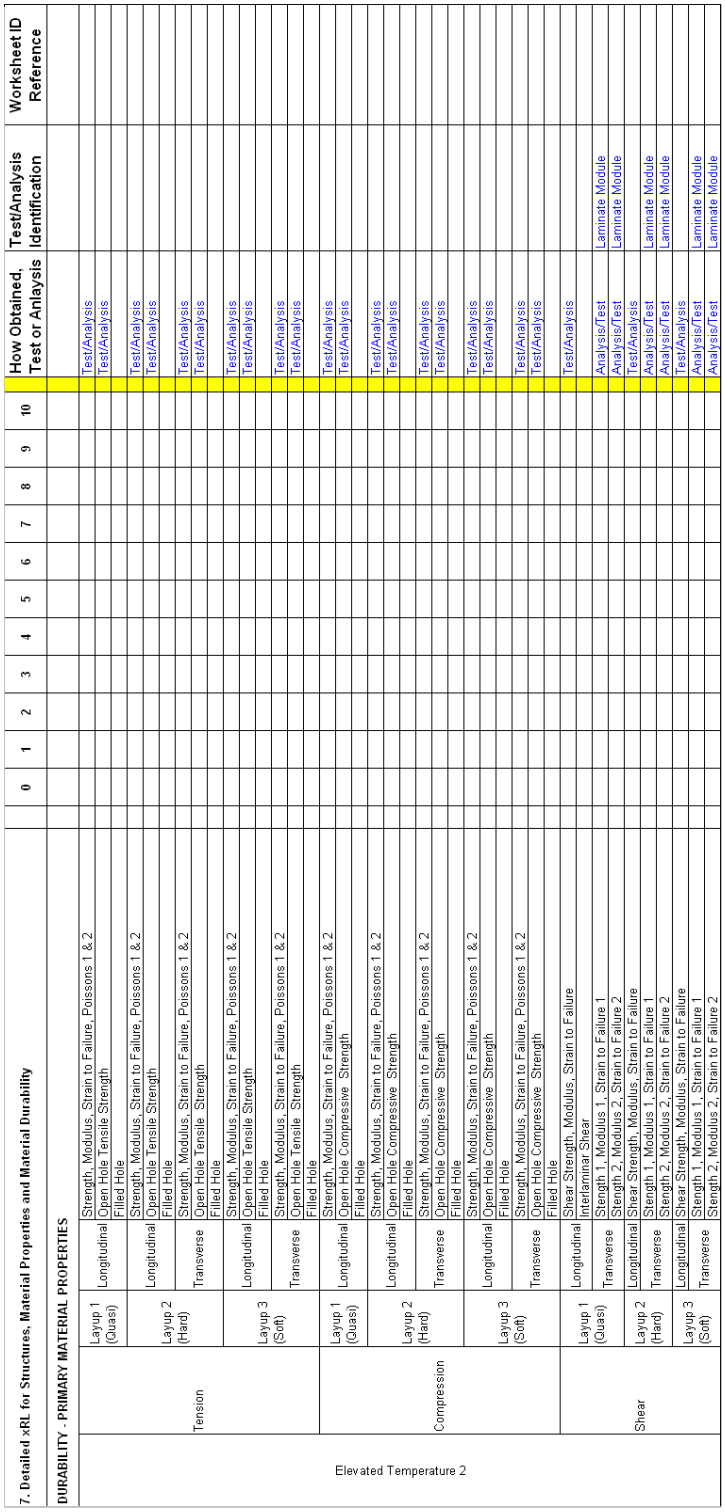
7. Detailed xRL for Structures, Material Properties and Material Durability					0	1	2	3	4	5	6	7	8	9	10	How Obtained, Test or Anlaysis	Test/Analysis Identification	Worksheet ID Reference
DURABILITY - PRIMARY MATERIAL PROPERTIES																		
Low Temperature	Tension	Layup 1 (Quasi)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
		Layup 2 (Hard)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
		Layup 3 (Soft)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
	Compression	Layup 1 (Quasi)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
		Layup 2 (Hard)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
		Layup 3 (Soft)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
	Shear	Layup 1 (Quasi)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Interlaminar Shear														
			Transverse	Stength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
				Stength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	
		Layup 2 (Hard)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Stength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
			Transverse	Stength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	
		Layup 3 (Soft)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Stength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
			Transverse	Stength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	

Figure D-11 Example Laminate Property and Durability Check Sheet, 3 of 7



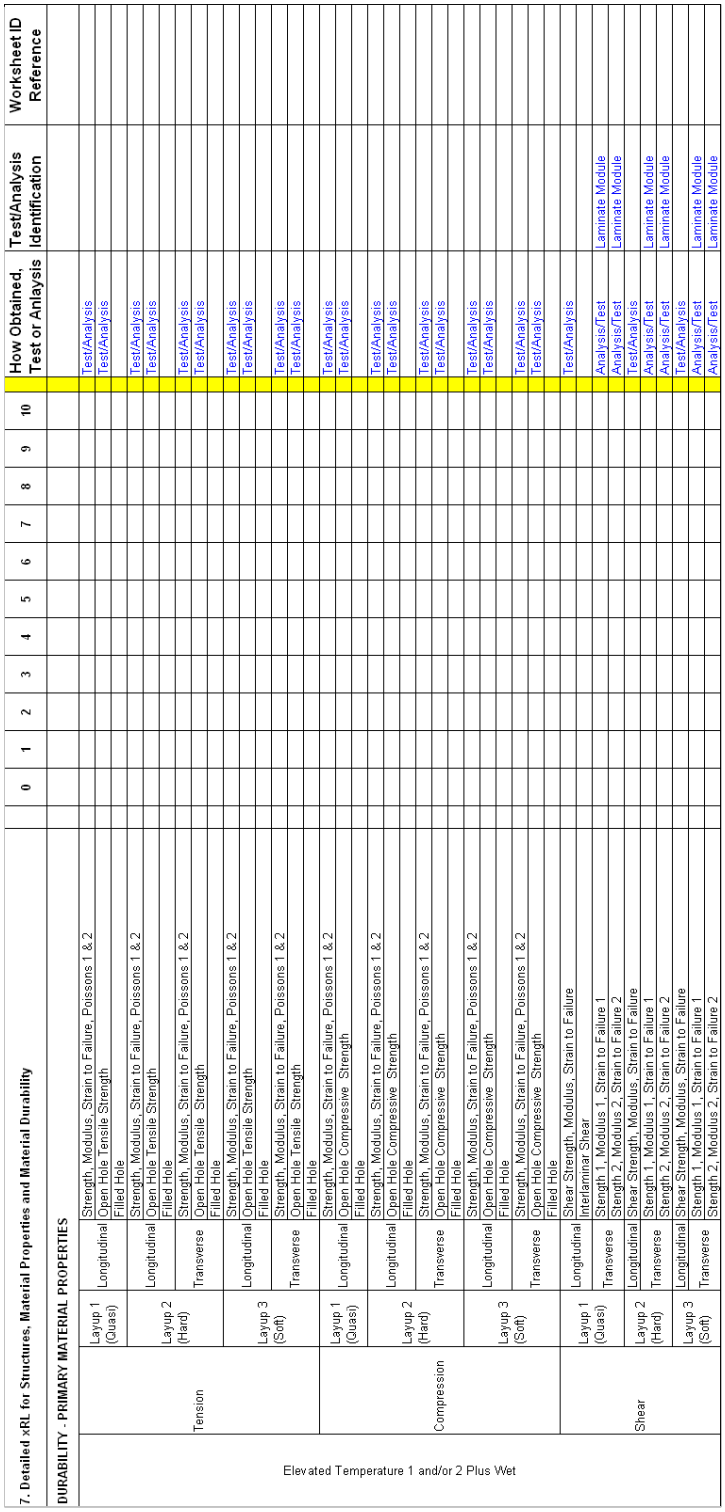
7. Detailed xRL for Structures, Material Properties and Material Durability					0	1	2	3	4	5	6	7	8	9	10	How Obtained, Test or Anlaysis	Test/Analysis Identification	Worksheet ID Reference
DURABILITY - PRIMARY MATERIAL PROPERTIES																		
Elevated Temperature 1	Tension	Layup 1 (Quasi)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
		Layup 2 (Hard)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
		Layup 3 (Soft)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
	Compression	Layup 1 (Quasi)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
		Layup 2 (Hard)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
		Layup 3 (Soft)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
	Shear	Layup 1 (Quasi)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Interlaminar Shear														
			Transverse	Strength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
				Strength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	
		Layup 2 (Hard)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Stength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
			Transverse	Stength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	
		Layup 3 (Soft)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Stength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
			Transverse	Stength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	

Figure D-11 Example Laminate Property and Durability Check Sheet, 4 of 7



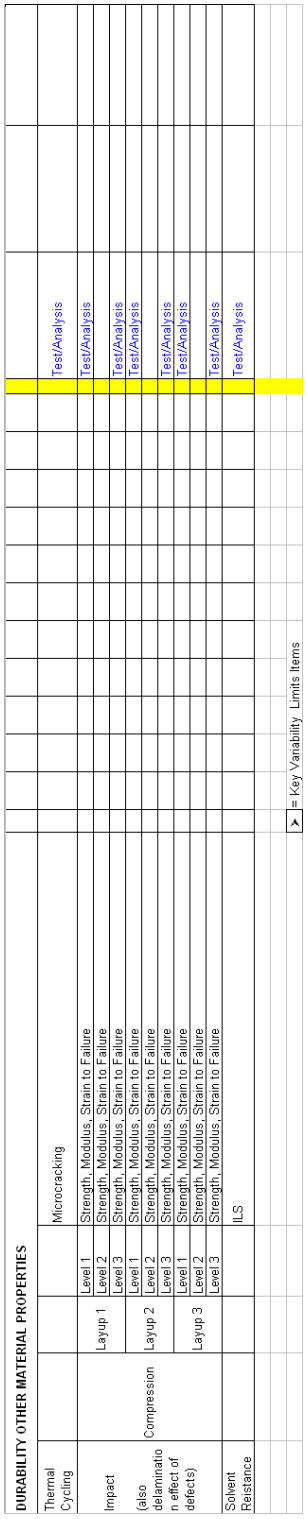
7. Detailed xRL for Structures, Material Properties and Material Durability					0	1	2	3	4	5	6	7	8	9	10	How Obtained, Test or Anlaysis	Test/Analysis Identification	Worksheet ID Reference
DURABILITY - PRIMARY MATERIAL PROPERTIES																		
Elevated Temperature 2	Tension	Layup 1 (Quasi)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
		Layup 2 (Hard)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
		Layup 3 (Soft)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Tensile Strength												Test/Analysis		
				Filled Hole														
	Compression	Layup 1 (Quasi)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
		Layup 2 (Hard)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
		Layup 3 (Soft)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2												Test/Analysis		
				Open Hole Compressive Strength												Test/Analysis		
				Filled Hole														
	Shear	Layup 1 (Quasi)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Interlaminar Shear														
			Transverse	Strength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
				Strength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	
		Layup 2 (Hard)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Stength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
			Transverse	Stength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	
		Layup 3 (Soft)	Longitudinal	Shear Strength, Modulus, Strain to Failure												Test/Analysis		
				Stength 1, Modulus 1, Strain to Failure 1												Analysis/Test	Laminate Module	
			Transverse	Stength 2, Modulus 2, Strain to Failure 2												Analysis/Test	Laminate Module	

Figure D-11 Example Laminate Property and Durability Check Sheet, 5 of 7



7. Detailed xRL for Structures, Material Properties and Material Durability						0	1	2	3	4	5	6	7	8	9	10	How Obtained, Test or Anlaysis	Test/Analysis Identification	Worksheet ID Reference
DURABILITY - PRIMARY MATERIAL PROPERTIES																			
Elevated Temperature 1 and/or 2 Plus Wet	Tension	Layup 1 (Quasi)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Tensile Strength													Test/Analysis		
				Filled Hole															
		Layup 2 (Hard)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Tensile Strength													Test/Analysis		
				Filled Hole															
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Tensile Strength													Test/Analysis		
				Filled Hole															
		Layup 3 (Soft)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Tensile Strength													Test/Analysis		
				Filled Hole															
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Tensile Strength													Test/Analysis		
				Filled Hole															
	Compression	Layup 1 (Quasi)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Compressive Strength													Test/Analysis		
				Filled Hole															
		Layup 2 (Hard)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Compressive Strength													Test/Analysis		
				Filled Hole															
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Compressive Strength													Test/Analysis		
				Filled Hole															
		Layup 3 (Soft)	Longitudinal	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Compressive Strength													Test/Analysis		
				Filled Hole															
			Transverse	Strength, Modulus, Strain to Failure, Poissons 1 & 2													Test/Analysis		
				Open Hole Compressive Strength													Test/Analysis		
				Filled Hole															
	Shear	Layup 1 (Quasi)	Longitudinal	Shear Strength, Modulus, Strain to Failure													Test/Analysis		
				Interlaminar Shear															
			Transverse	Stength 1, Modulus 1, Strain to Failure 1													Analysis/Test	Laminate Module	
				Stength 2, Modulus 2, Strain to Failure 2													Analysis/Test	Laminate Module	
		Layup 2 (Hard)	Longitudinal	Shear Strength, Modulus, Strain to Failure													Test/Analysis		
				Stength 1, Modulus 1, Strain to Failure 1													Analysis/Test	Laminate Module	
			Transverse	Stength 2, Modulus 2, Strain to Failure 2													Analysis/Test	Laminate Module	
		Layup 3 (Soft)	Longitudinal	Shear Strength, Modulus, Strain to Failure													Test/Analysis		
				Stength 1, Modulus 1, Strain to Failure 1													Analysis/Test	Laminate Module	
			Transverse	Stength 2, Modulus 2, Strain to Failure 2													Analysis/Test	Laminate Module	

Figure D-11 Example Laminate Property and Durability Check Sheet, 6 of 7



DURABILITY OTHER MATERIAL PROPERTIES					
Thermal Cycling				Microcracking	
Impact (also delaminination effect of defects)	Compression	Layup 1	Level 1	Strength, Modulus, Strain to Failure	Test/Analysis
			Level 2	Strength, Modulus, Strain to Failure	
			Level 3	Strength, Modulus, Strain to Failure	
		Layup 2	Level 1	Strength, Modulus, Strain to Failure	Test/Analysis
			Level 2	Strength, Modulus, Strain to Failure	
			Level 3	Strength, Modulus, Strain to Failure	
		Layup 3	Level 1	Strength, Modulus, Strain to Failure	Test/Analysis
			Level 2	Strength, Modulus, Strain to Failure	
			Level 3	Strength, Modulus, Strain to Failure	
Solvent Reistance				ILS	Test/Analysis

= Key Variability Limits Items

Figure D-11 Example Laminate Property and Durability Check Sheet, 7 of 7

Operation	Activity	0.25	0.50	0.75	1	2	3	4	5	6	7
Hand Cutting	Requirements				X						
	Spool Information				X						
	Indirect Materials ID/Compatability				x	X					
	Tack, Original				X						
	Tack, Out Time				X		X				
	Tack, Freezer Time						X				
	Variability, Dimensions				X						
	Variability, Angle				X						
	Specification, Draft Items/Areas				X	X					
	Specification, Preliminary						X				
	Specification, Final							X			
Hand Layup	Requirements				X						
	Indirect Materials ID/Compatability				x	X					
	Tack, Original (lay down and removal)				X						
	Tack, Out Time (lay down and removal)				x		X				
	Tack, Freezer Time						X				
	Variability, Dimensions				X						
	Variability, Angle				X						
	Specification, Draft Items/Areas				X	X					
	Specification, Preliminary						X				
	Specification, Final							X			
Debulking	Requirements				X						
	Indirect Materials ID/Compatability				x	X					
	Methods, Plies/Times/Temps/Pressures				x	X					
	Limits, Plies/Times/Temps/Pressures					x					
	Specification, Draft Items/Areas				X	X					
	Specification, Preliminary						X				
	Specification, Final							X			
Bagging	Requirements				X						
	Indirect Materials				x	X					
	Edge Gaps, Initial				X						
	Edge Gaps, Limits					X					
	Specification, Draft Items/Areas				X	X					
	Specification, Preliminary						X				
	Specification, Final							X			
Cure	Requirements				X						
	Initial Times/Temps/Pressures				X						
	Material Combinations				X						
	Limits, Times/Temps/Pressures					X					
	Limits, Heat up/Cool Down/Tooling/Equipment				x	X					
	Specification, Draft Items/Areas				X	X					
	Specification, Preliminary						X				
	Specification, Final							X			
Tooling					x	x	X	x			
NDE					x	X	X	x			
						=	Primary Activity				

Figure D-12 Example Producibility Operations Check Sheet

Area	Item	Activity	0.25	0.50	0.75	1	2	3	4	5	6	7
In-Process Qulaity	Cutting	Times				x						
		Temperatures				x						
		Dimensions				x						
		Angles				x						
		Indirect Manterial Compatability				x	x					
		Limitations					x					
		Specification, Draft Items/Areas				x	x					
		Specification, Preliminary						x				
		Specification, Final							x			
	Hand Layup	Times				x						
		Temperatures				x						
		Pressures				x						
		Indirect Material Compatability				x	x					
		Dimensions				x						
		Angles				x						
		Limitations					x					
		Specification, Draft Items/Areas				x	x					
		Specification, Preliminary						x				
		Specification, Final							x			
	Debulking	Plies				x						
		Times				x						
		Temperatures				x						
		Pressures				x						
		Indirect Material Compatability				x	x					
		Limitations					x					
		Specification, Draft Items/Areas				x	x					
		Specification, Preliminary						x				
		Specification, Final							x			
	Bagging	Indirect Material Compatability				x	x					
		Edge Gaps				x						
		Limitations					x					
		Specification, Draft Items/Areas				x	x					
		Specification, Preliminary						x				
		Specification, Final							x			
	Cure	Times				x						
		Temperatures				x						
		Pressures				x						
		Aborts					x					
		Limitations					x					
		Specification, Draft Items/Areas				x	x					
		Specification, Preliminary						x				
		Specification, Final							x			
	Other	Out Time				x		x				
		Freezer Time						x				
							=	Primary Activity				

Figure D-13 Example Producibility In-Process Quality Check Sheet

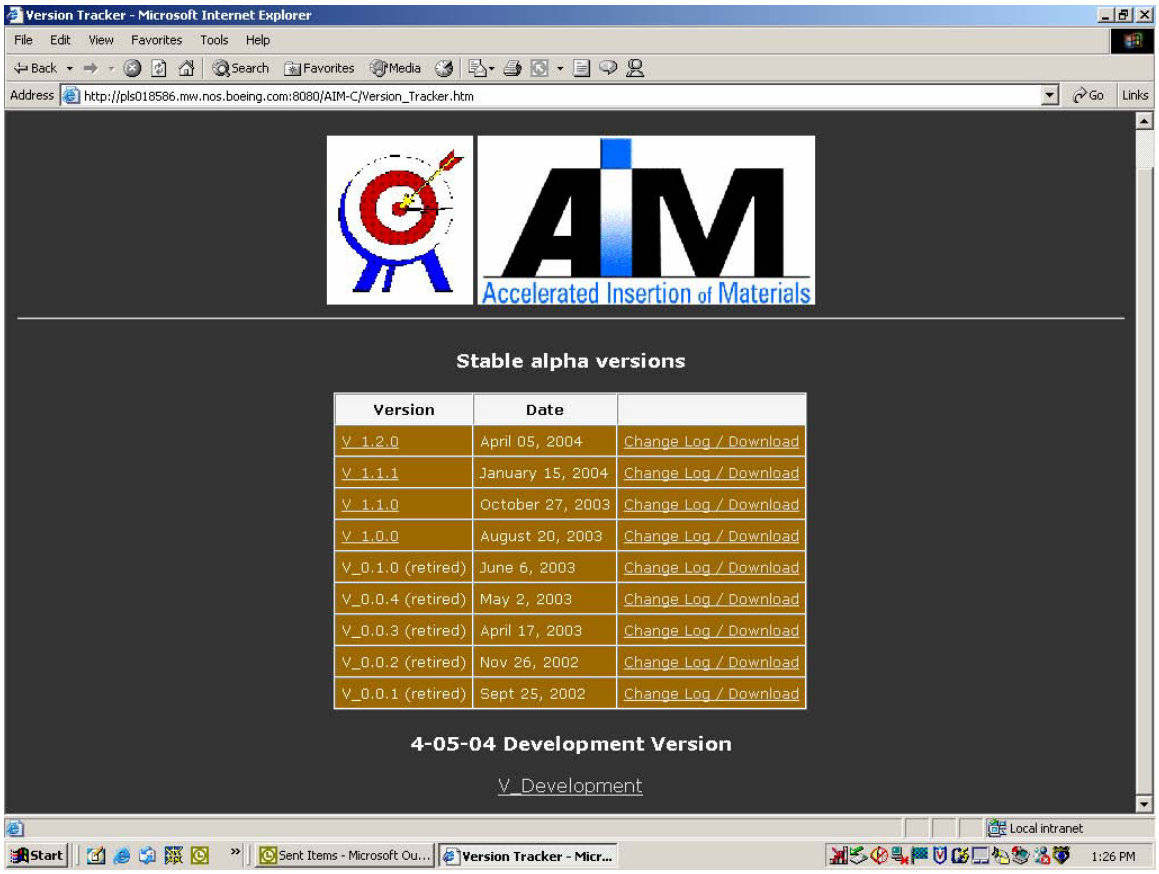
Area	Item	Activity	0.25	0.50	0.75	1	2	3	4	5	6	7
Final Quality	Voids/ Porosity	Debulking				x						
		Bagging				x						
		Cure				x						
		Flat Panels				x						
		NDE Defect Detectability				x	x					
		NDE Defect Detectability Limits				x	x					
		Ramps				x						
		Multiple Thickness Flat Panels					x					
		NDE Thickness Standards					x					
		Hats					x					
		NDE Multiple Material Standards					x					
		Size Scale up				x		x				
		Specification, Draft Items/Areas				x	x					
		Specification, Preliminary						x				
		Specification, Final							x			
	Delaminations/ Inclusions	Indirect Material Detectability				x						
		Indirect Material Detectability Limits					x					
		Multiple Material Separation Detectability					x					
		Specification, Draft Items/Areas				x	x					
		Specification, Preliminary						x				
		Specification, Final							x			
	Thickness	Material Capability				x						
		Producibility Capability				x	x					
		Specification, Draft Items/Areas				x	x					
		Specification, Preliminary						x				
		Specification, Final							x			
	In-Plane Fiber Distortion							x				
								x				
	Out of Plane Fiber Distortion							x				
								x				
	Other	Effects of Defects					x	x	x			

= Primary Activity

Figure D-14 Example Producibility Final Quality Check Sheet

Appendix E - Accelerated Insertion of Materials – Composites (AIM-C): Users Manual

By Alison Ruffing



The original issue of this document was jointly accomplished by Boeing and the U.S. Government under the guidance of NAVAIR under N00421-01-3-0098, Accelerated Insertion of Materials – Composites.

Table of Contents

List of Figures

1. AIM-C Methodology and System

The AIM-C System provides a modeling environment capable of solving a broad range of complex problems by integrating together a host of modules, databases or other elements. Users are able to create a product's design, manufacture, and support knowledge base, starting with a problem statement, customer needs, and the certification agencies requirements.

The AIM-C methodology provides a disciplined process for materials insertion. The methodology does the following things: (1) captures the problem statement, (2) guides the Integrated Product Team (with technology and application development members) through requirements development, (3) facilitates conformance planning and provides tools for studies which can assess interactions, importance, and show-stoppers important to planning for qualification and certification conformance, (4) provides for documentation of knowledge generated by use of heuristics, lessons learned, and existing knowledge, by analysis, and by test with associated confidence levels, and (5) facilitates conformance assessment and committal of the knowledge base to the master.

The AIM-C methodology was built using ground rules: (1) the building block approach is integral to the insertion process (2) all relevant disciplines are involved, (3) testing is focused on needs that are identified through analysis and the current knowledge base, and (4) the insertion process targets long lead concerns, unknowns, and areas predicted to be sensitive to changes in materials, processing, or environmental parameters.

A feature of the AIM-C methodology is that the AIM-C system maintains three important characteristics: (1) any given piece of information resides in only one element (module, data set, etc), thus the system can quickly grow to adapt to a broad range of problems with minimal conflicts and programmer-intervention, (2) each element of the system has an owner or expert that updates, maintains and provides technical services to the user community, and (3) the database created by use of the system can be certified, meaning all elements and the system are validated, verified, uniquely identified and traceable.

1.1 Software Documentation

The AIM-C system was created with a variety of documentation depending on what aspect the user is looking at. This section will give a brief overview of the codes behind the scenes and how it works.

The interface currently uses a basic html (hypertext markup language) and Java Server Pages (JSP) style. The html is the page that actually displays in the browser. It contains the pictures and text that the user will see. The JSP is the code that provides capability to the developer to create the html pages. JSP facilitates a number of things behind the scenes to get the information to the user. For instance regular Java code can be called from the JSP that will retrieve and send data to a Microsoft Access database. It allows

the developer to do calculations and execute complex logical statements to decide what the html page will display.

For the AIM-C GUI, java code is used in conjunction with SQL (Standard Query Language) to connect to the MS Access database using JDBC (Java Database Connectivity). There are a number of routines that are used to perform the tasks expected in the GUI. For instance, SQL commands retrieve all information from the database, update information in the database, grab any columns or rows, and create tables in the database. These are used to connect the GUI information with the database.

Other software involved is the Microsoft Access database. The current version is Windows 2000 compatible. Initially the administrator must connect the database using the Administrative Tools: Data Sources: ODBC connections. This is done only once by the administrator for each database used.

In order to make a computer act as a web server, the free software package called Apache Tomcat 4.0 is used to simulate a server situation. This allows the JSP pages to "compile" each time the page is hit. This means each page will update and perform the tasks in the code for every action the user performs. The Apache software must be started in order for the pages to display properly. This involves starting a command prompt window and starting up the Tomcat application, which creates the Catalina window application prior to the execution of the GUI. Generally the window is able to stay open for days without problems, thus it does not need to be restarted each time the GUI is executed, but can be left running in the background. If the Catalina window is closed, the computer will no longer act as a server and users will be unable to connect.

In order to run the Java code, the machine will need to have JAVA SDK 1.3 installed. After this is installed, system variables will need to be defined appropriately. These are JAVA_HOME, CATALINA_HOME, and CLASSPATH.

The java codes used in this application must be placed in packages and JAR (Java TM Archive) files for use. The JAR files must be placed inside a directory where Tomcat can use it. In the AIM-C case, this is in the Web-INF folder.

Often during the development process the JSP and html pages would not update when changed. One reason for this was that the Tomcat work directory did not compile new (or changed) pages on the fly like it was intended to do. Often the programmers needed to delete the work directory where the compiled files were stored to get a clean start on the GUI pages.

Tomcat also has a problem serving pages if the directory of the pages is different than its own. For instance, if Tomcat was installed on the C: drive, the html and jsp codes should reside there, too. It is recommended that all AIM-C GUI codes reside on the C: drive.

Another minor step is to make sure that Internet Explorer will check for new versions of pages. This is done by launching I.E., going to the Tools menu, opening the Internet

Options, and on the General tab, selecting the Settings button. This will bring up a screen where the default check should be set to every visit to every page. This will prevent old cached pages from being displayed if a new version exists.

Separate Java code is used to validate the user, password, and groups at the login screen. This is done to prevent groups from getting information they should not have. Once the username is validated against the password, the group is checked to see what projects are available to that group. Members of the team have provided a project manager, which is responsible for things like starting new projects, copying, deleting, and listing current projects.

To run the system, a laptop can be plugged into the Boeing dataline at any Boeing site. It will connect to a personal computer in St. Louis, which acts like a server. All of the pages are sent to the laptop through the I.E. browser. When the RDCS template run is initiated, the St. Louis server connects with the UNIX or Linux machines at Canoga Park, CA. The output is collected and sent to St. Louis to be displayed in the laptop or saved in the database. This provides a clear demonstration that the GUI will work no matter where the user is located. A simple sketch is shown in Figure E - 1 to clarify the connections, where the laptop is located in Seattle. A down side to this system is that currently; a user must be logged onto the Boeing network to avoid any firewall issues.

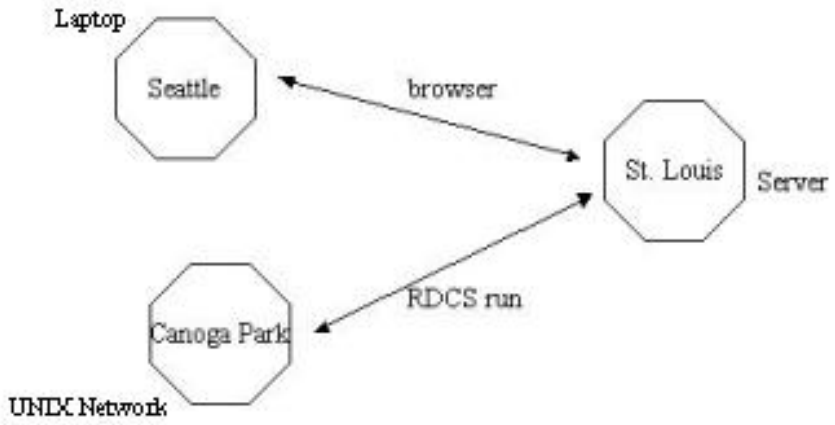


Figure E - 1. Map of Network Calls to Run Templates

If the GUI system is installed on a non-Boeing laptop, the functionality may not act the same, especially when running templates or accessing Boeing internal links. These will have to be set up on the non-Boeing system in the same fashion as the Boeing system. Therefore, the network map above would be altered for each separate system.

1.2 Pedigree

The pedigree of the software, the data, and all components relating to the AIM-C system is captured in a number of different ways.

The material data in the system has been marked with its own pedigree. Every test that takes place should have a pedigree that states what was done, how it was done, the date it was performed, and other significant data that the user should know. There is a place for this information for every material property that is placed in the readiness level charts. There are notes, pedigrees, and comments textboxes for every readiness level available. Between these three boxes, the test should be described or a Test Request Number should be mentioned. Many of the properties will have other associated data with them, such as which test was performed to get that specific information.

The pedigree of the executable codes is listed on the modules download page. All of the codes are downloadable from this page. After each hyperlink to the code, there is a date and a version number to keep track of the progression of each code. The user will have to install them on their own personal computer to get them to work. Some of these may need licenses to run. All of the codes are also in WINCVS on the correct system they were created on.

The codes and data have also been through a configuration control process where it has been placed in a file revision control area. Old versions of these codes can be recalled at any time.

The AIM-C interface software has been kept in a file revision storage area. The program that manages this is called WINCVS (Figure E - 2). It is located on the Boeing Canoga Park, CA machines. WINCVS keeps track of all the changes that occur on each of the files. If a file has been changed or modified, the file will show up as a red icon and will need to be committed into the repository. If a file has a question mark as an icon, the file is not captured in the system and changes will not be tracked. If a file icon shows up as a text box, the file is current. All of the folders that are tracked in WINCVS are designated by a check mark on the box. There are features about this program, where it will display the changes made from version to version and list the revision number and modified date for each file. The common user does not use this program.

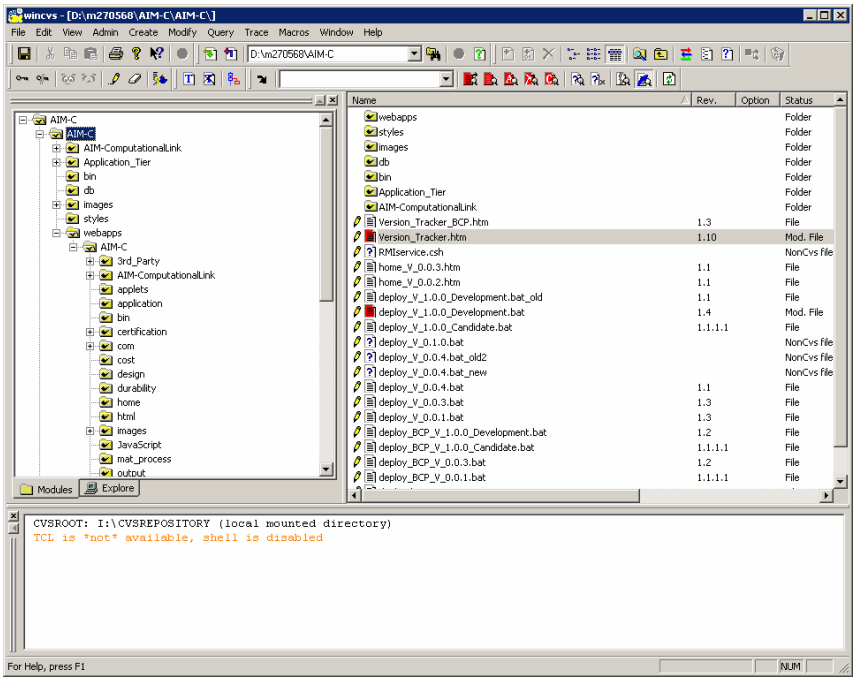


Figure E - 2. WINCVS Version Control Software

All of the executable codes that are run in the templates are also revision controlled. Each time the codes were updated, they were given a new revision number and controlled by the Seattle WINCVS server. So, the pedigree of the templates is controlled as well.

2.0 User Walk-Through and How-To Pages

2.1 Version Tracker

The AIM-C Version Tracker is used as a release bed for each new version of the software. The initial version of the software was called alpha minus and was updated daily. Unfortunately, the user had to be aware that at any time the system could be down. The Version Tracker was implemented in September 2002 to create a stable version of the software to use at any given time. The first version was V_0.0.1, which has progressed all the way to the Alpha system. Along with the current version, there has always been a development version of the software. This is to give access to the all the developers so they can update and enhance the software while testing it in the environment it was intended to be used.

After a version of the software has become obsolete, the link on the Version Tracker page is removed. This forces the users to use the latest and greatest information and GUI. This can be seen in Figure E - 3.

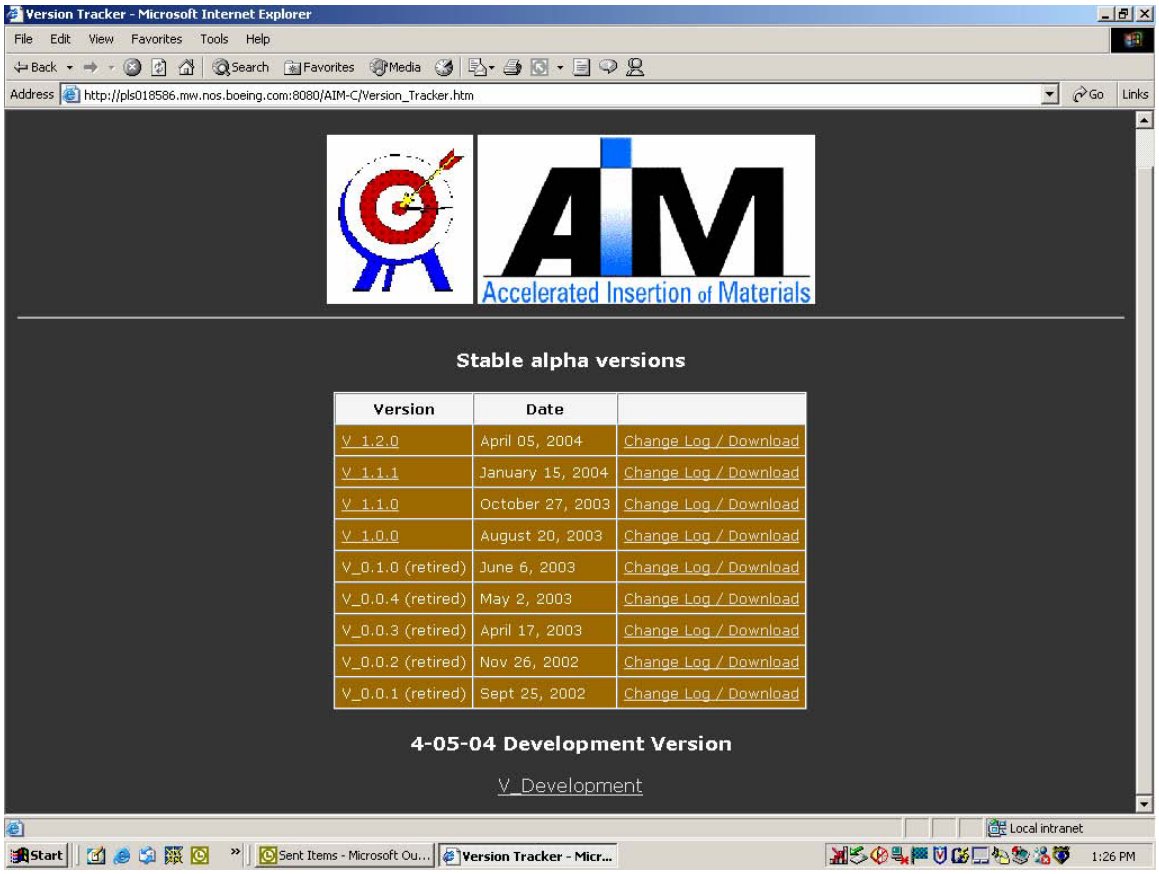


Figure E - 3. Version Tracker Page

On the Version Tracker Page, there is also a downloadable page called “Change Log/ Download”, which contains descriptions of the modifications for that version, dates of past releases, and a list of downloadable resources that the user may need in order to run the AIM-C system. Some of these resources include Java Development Kit, Tomcat Engine, Java 3-D, COS (Server Utilities), Java Expression Parsing, Python, and a Boeing Web Based Engineering Environment. This can be seen in Figure E - 4.

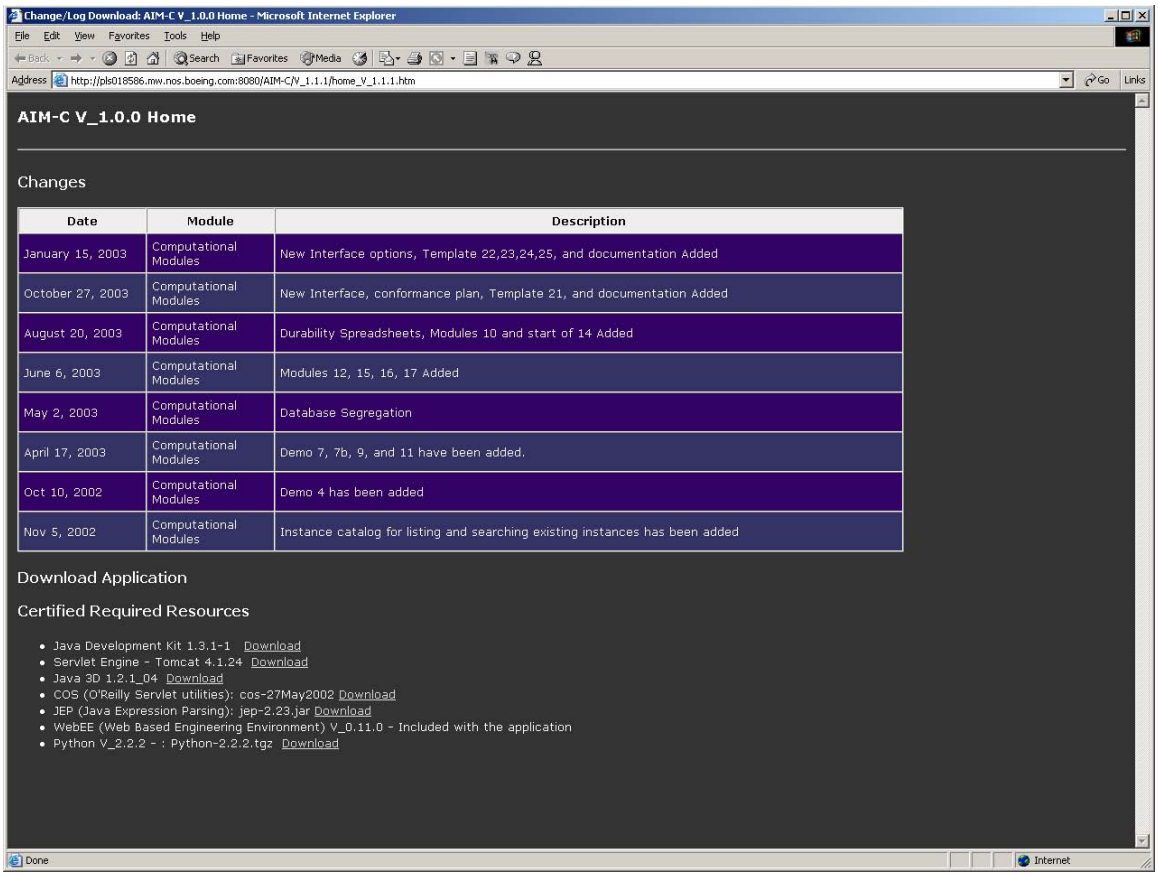


Figure E - 4. Download and Changes Page

To start using the AIM-C GUI, click on the Version Tracker page the version number. Generally the most recent version number is suggested, which is the one on the top of the list. After the button is clicked the Legal Rights page will show up.

2.2 Rights/licensing

AIM-C Software and System was developed under contract. The following information pertains to the rights and licensing of the AIM-C system.

1) Use, duplication, or disclosure is subject to the restrictions as stated in Agreement No. N00421-00-3-0098 between the U.S. Government and BOEING. RESTRICTION OF DISCLOSURE OF USE OF DATA.
Distribution authorized to U.S. Government agencies only to protect information not owned by the U.S. Government and protected by a contractor's "limited rights" statement, or received with the understanding that it not be routinely transmitted outside the U.S. Government. Other requests for this document shall be referred to NAVAIR Technical Information Officer.

2) Certain of the included/enclosed technical data is provided in support of use of the software/system developed under Agreement No. N00421-00-3-0098. It is to be used only in support of the authorized Government programs. As such, this data may not be

shared with any non-U.S. party who has not previously been approved in writing by the U.S. Department of State. This definition includes other entities of the foreign parties to this TAA not located in their respective countries.

3) a. Warning: This software/system/data contains or may contain technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C. Section 2751 et. seq.) or the Export Administration Act (50 U.S.C. App. 2401). Violation of these export laws is subject to severe criminal penalties.

b. 22 CFR 125.4(b)(2)- data does not exceed the scope of the agreement or limitations/provisos imposed thereto by the Department of State. (Reference 22 CFR125.6(a) and 124.3(a)).

4) Certain portions of the software used in this system are provided by contractors to the U.S. Government and such software is or may be copyrighted by such contractor(s) and other restricted/limited rights apply or may apply thereto and duplication and other usage is not permitted.

5) Boeing provides this software and data "as is" and makes no warranty, express or implied, as to the accuracy, capability, efficiency, or functioning of the product.
In no event will Boeing be liable for any general, consequential, indirect, incidental, exemplary or special damages, even if Boeing has been advised of the possibility of such damages.

After the user has read this page, in order for the user to proceed, they must pick the “Accept Terms” button. If they accept, this will lead them to the login screen. If they do not accept, it will push them back to the Version Tracker page. A sample of what this page looks like is shown in Figure E - 5.

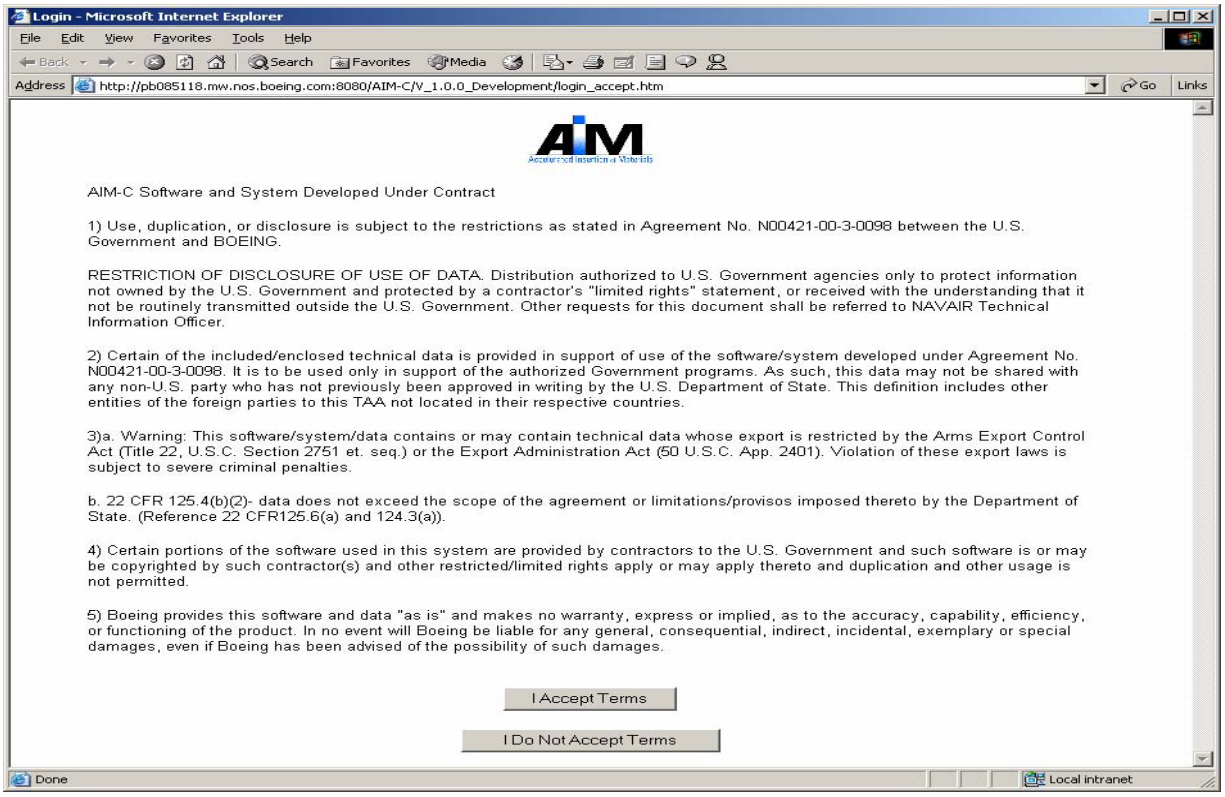


Figure E - 5. Rights and Legal Page

2.3 Login

Figure E - 6 shows the initial login screen that the user sees when he or she accesses the website. The username and password should be given along with the group to which the user belongs. All three of these are validated using Java code supported by a database. The group is the key element that allows users to view and edit projects only within their group. This will prevent different people from getting data that they should not have. A system administrator will assign a new user the username, password, and group upon request. At that time a new entry is placed in the user database for validation.

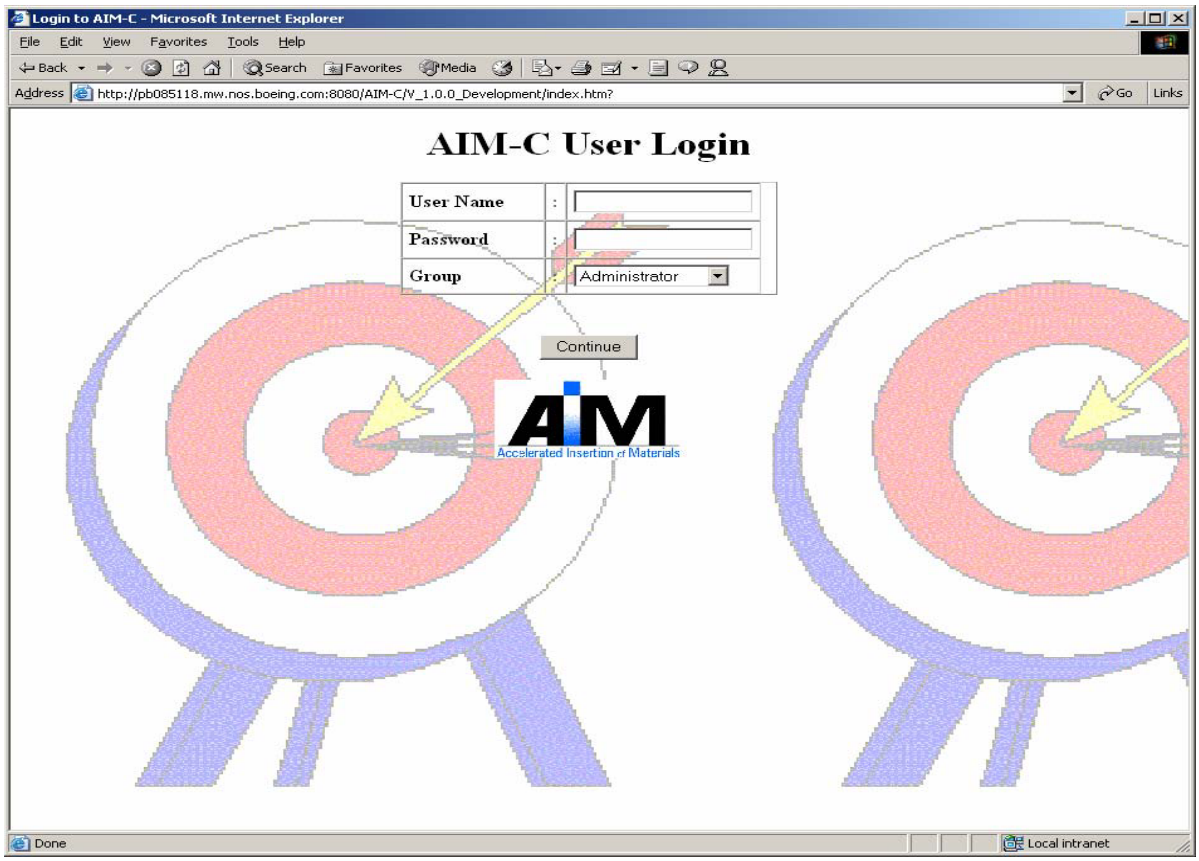


Figure E - 6. Login Screen

The only one who can change and add usernames, groups, and passwords is the system administrator. They will have to manually change this information in the database each time a new request for a user is made. Once the initial request has been processed, the user can access the system indefinitely.

For demonstration purposes, the following can be used to get into the system.
Username: a
Password: a
Group: Demo

After these have been typed in, the user must push the "Continue" button. A validated username and password will lead the user to the project manager.

2.4 Project Manager

The project manager was created to give each user group a set of projects. These projects can be created or altered by only the members of that group. When a project is created, the Part Number, Program, Designer, Description, and Time Stamp are recorded. They are then used to differentiate projects. Within the project manager, the user can specify if they want to start a new project, open an existing project, copy a project to another name, delete the project, rename the project, or list all available projects in the user's group.

It is best to choose a project name or Part Number that is very descriptive. The name cannot contain spaces or special characters. It is best to use only letters, numbers, and underscores combinations to signify project names. The Program, Designer, and Description can be used to fill in more detailed information. When building a new database for a project, it may take ten to fifteen seconds for the load to complete. Once all the data is satisfied, the process will bring the user directly to the AIM-C home page.

While these tasks are transparent to the user, a lot of work is done to the database each time one of these buttons is implemented. Every time a button is pushed, many tables in the database are touched. For instance, when a new project is created, rows in the tables in the database are created using defaults. All of these rows contain data from the user with the project name as its search criteria. Likewise, when a project is deleted, all the rows in all the tables that can be altered by the user are erased. This can cause a small wait of ten to fifteen seconds before the browser returns to a working state. In most cases, the user will select and work on the same project until that material system analysis is done. To select a project, the user must pick the radio button on the right side of the project manager in the "Selected" column and hit the "Open" button on the right side of the menu bar. This can be seen in Figure E - 7.

The first thing that the user must do in the insertion process is to set up the DKB (design knowledge database). This can be done on the Application and Certification screens that are pull-downs from the AIM-C home page.

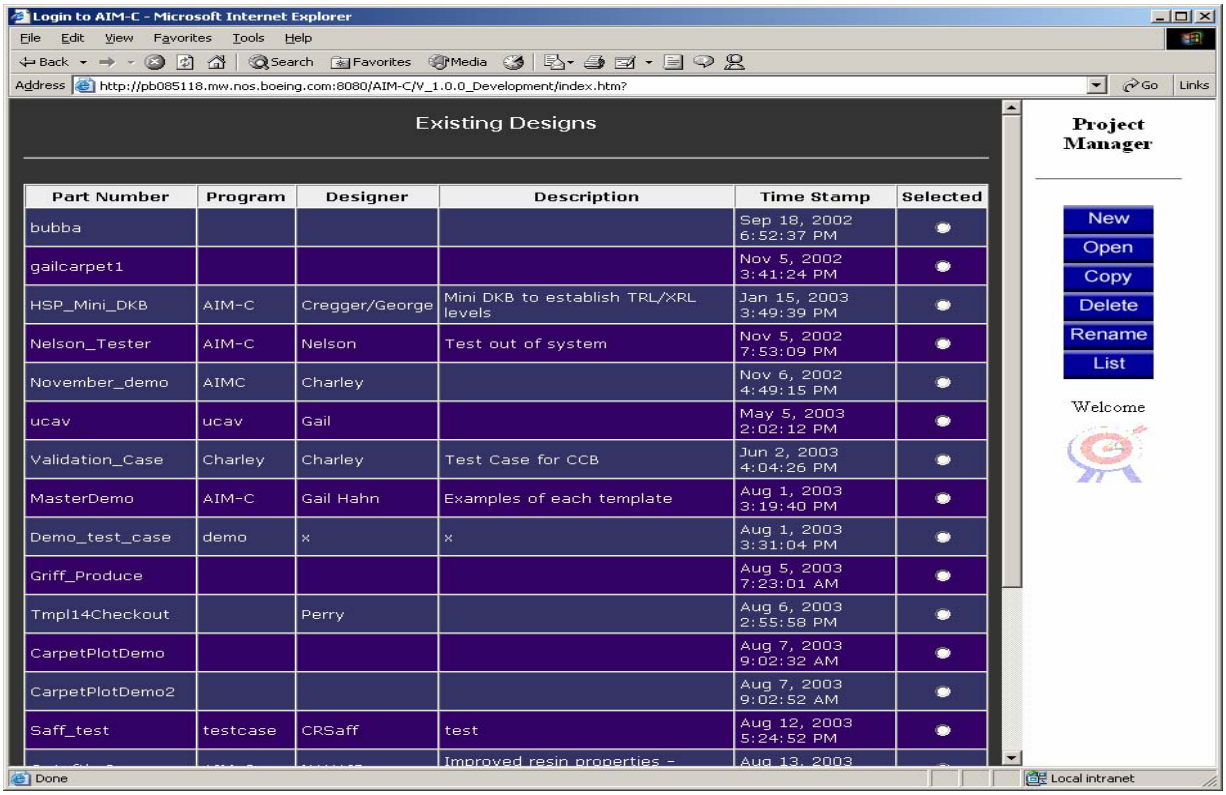


Figure E - 7. Project Manager Screen

The first time a user enters the Project Manager page, they should hit the "New" project button on the right side of the screen. After a brief ten-second wait, the software will open up the main page of the AIM-C GUI, and all the inputs will be set to default values.

2.5 Main Menu

The main menu is the place where the user should be able to get to any location within three clicks. This was designed to create a user-friendly environment where navigation would be intuitive. The user would start on the upper left menu and work their way down the first set of submenus. After they complete the information required for these picks, they can proceed to the right on the top of the menus and travel down those. The menu system across the top of the AIM-C GUI is the best way to navigate through the system. The drop-down menus serve as expandable areas where more information is located and can be reached. The first item on the menu is the AIM-C logo, which will bring the user back to the home page. As the user runs the cursor across the top of the menu structure, the categories will highlight and sub-categories will appear underneath.

The topics for the menus include Process Guidelines, Test Databases, Lessons Learned, Analysis templates, and About AIM-C. An example of this is seen in Figure E - 8.

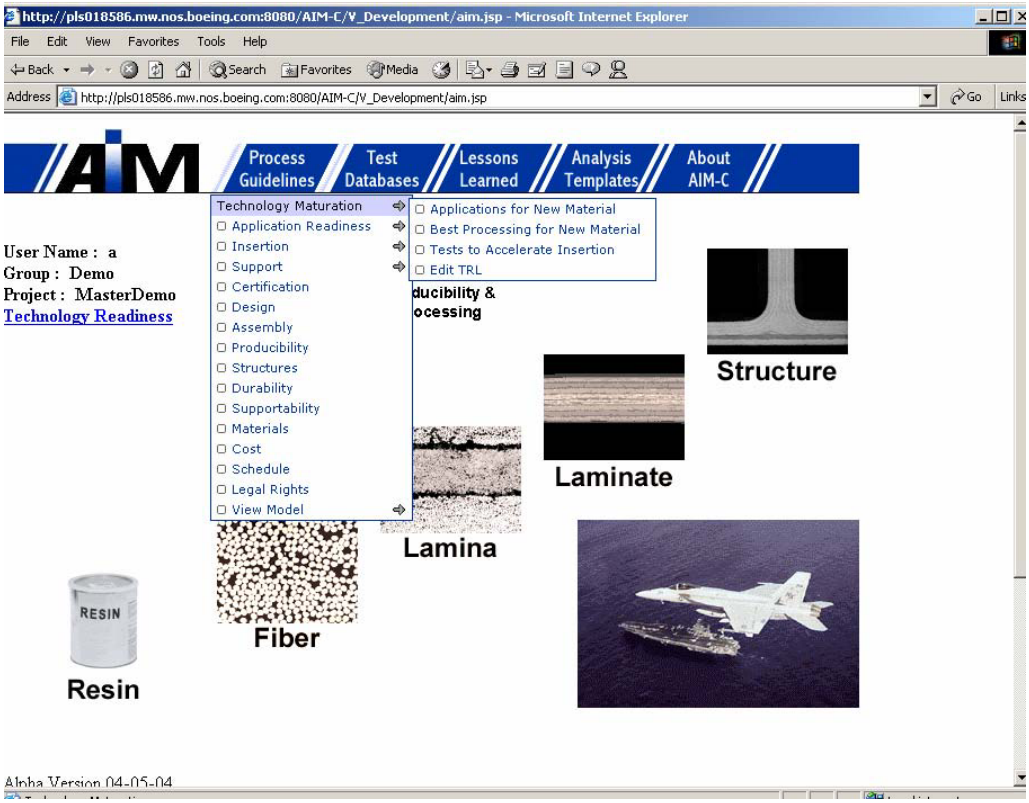


Figure E - 8. Drop Down Menu View

2.6 Home

The home screen of the AIM-C GUI is designed to help the user find their way through the system with efficiency. An example of this page is shown in Figure E - 9. The main menu is across the top of the screen. The home page also has a series of pictures representing different readiness levels for the different components of the material insertion process. If the user clicks on a picture, the software will load the readiness level for that component. These include resin, fiber, lamina, laminate, structure, durability, and producibility. Also on this page is the User Name, Group, and Project. This is to clarify which project the user is in. There is also a link to the Technology Readiness Level on the main screen. The specifics of these are describer later.

Underneath the pictures are a series of links that may help the user find information on other websites. Some of these are internal and some are external to Boeing. The links include Methodology for AIM-C documents, Test Methods for New Materials, New Process, and Second Source Data, Boeing PEPR (Production Engineering Publication Records) hotlink, MIL Handbook 5, MIL Handbook 17, ASTM documentation, EMDS - Engineering Materials Data System, Static Material Allowables hotlink which includes Boeing Design Manuals, PSDS, Engineering Sciences Data Unit (ESDU), Boeing Material and Process Specifications (BMS, BAC), Douglas Products Division Specifications (DMS, DPS), Douglas Products Division specs on Process, Material and Quality Standards site, ISDS - St. Louis Specifications (MMS, MPS), ASTM Standards, and Boeing Documents, DOD, ASTM, and SACMA Specifications.

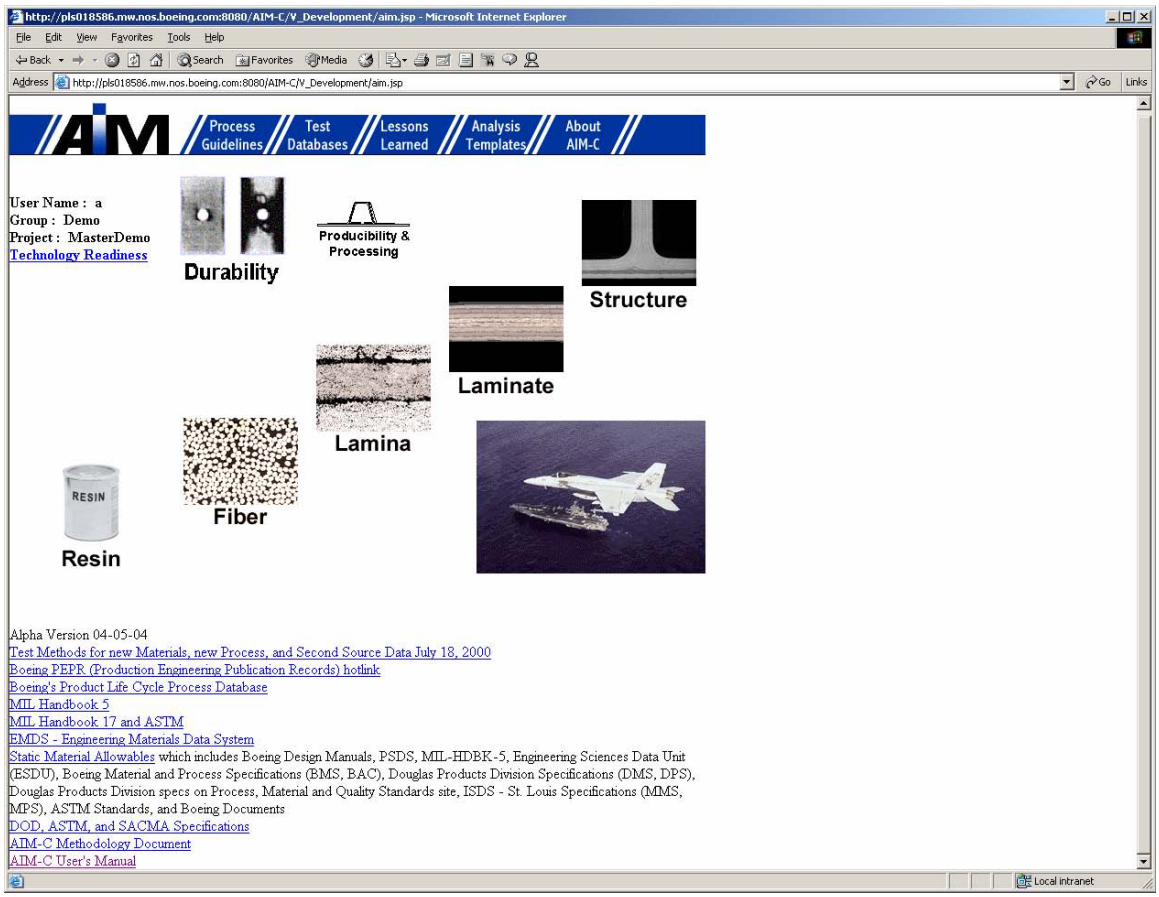


Figure E - 9. Main Page of AIM-C Software

2.7 Application

The first Application screen (Figure E - 10) asks the basic questions, such as what project, program, vehicle, component, and sub-component the user is working on. It also asks what processes are going to be used and what material system is being considered. This is the first piece in going through the methodology process flow. The process leads the user through questions at the TRL (Technology Readiness Level) and the XRL (X-underlying technology Readiness Level). At this level the requirements and major decisions are discussed. This leads down the path to properties and characteristics, which describe more information on each level. Under this level are worksheets, templates, details, and lessons learned. This methodology is used throughout each TRL level of the GUI.

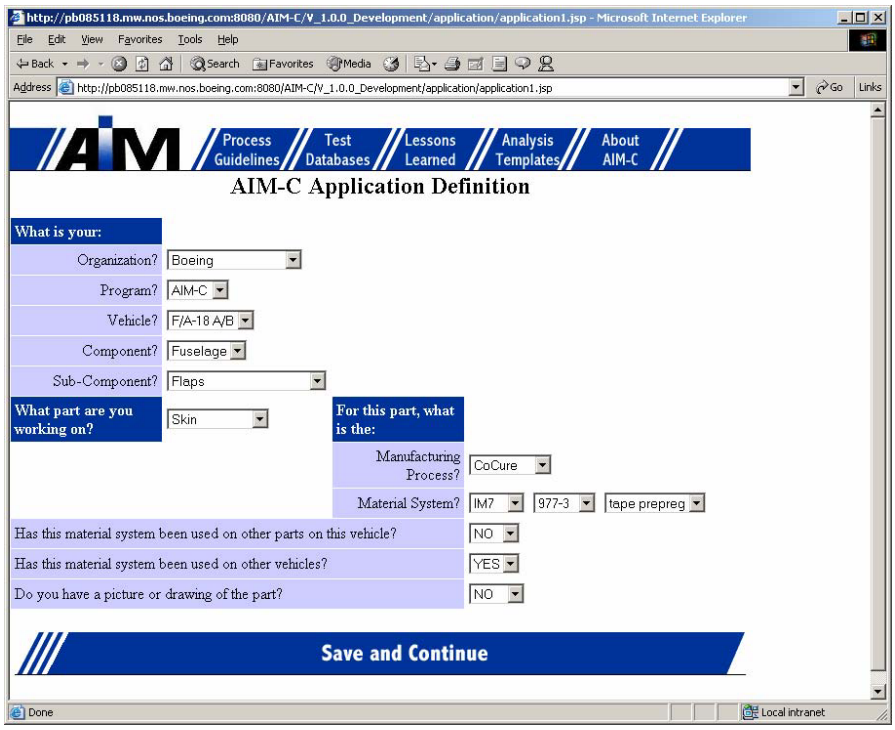


Figure E - 10. Application Definition

The second screen in the Application menu (Figure E - 11) asks the user what phase of production the product is in. This is represented by a series of radio buttons, which the user can change while the product is maturing. The last screen of the application section asks if there is documentation available for additional information. Eventually, the GUI will save this documentation in a version controlled directory structure.

AIM-C Application Maturity

Do you have estimated properties?	◉ YES	○ InWork	○ Problem	○ NO	○ N/A
Do you have mechanical properties?	◉ YES	○ InWork	○ Problem	○ NO	○ N/A
Are you documenting manufactuing processes?	◉ YES	○ InWork	○ Problem	○ NO	○ N/A
Are you developing allowables?	◉ YES	○ InWork	○ Problem	○ NO	○ N/A
Are you testing subcomponent assemblies?	◉ YES	○ InWork	○ Problem	○ NO	○ N/A
Are you testing full scale components?	○ YES	○ InWork	○ Problem	◉ NO	○ N/A
Is this product in full scale ground test?	○ YES	○ InWork	○ Problem	◉ NO	○ N/A
Is this product in flight test?	○ YES	○ InWork	○ Problem	◉ NO	○ N/A
Is this product in production?	○ YES	○ InWork	○ Problem	◉ NO	○ N/A
Is this product out of production?	○ YES	○ InWork	○ Problem	◉ NO	○ N/A

Figure E - 11. Application Maturity Chart

2.8 Certification

The Certification menu is the next step in setting up the DKB. This asks the user what is documented, what is in test, and what is approved in the set up portion of the GUI as shown in Figure E - 12.

In the certification section of the GUI, there are numerous charts that reflect the inputs required for the Joint Services Specification. This leads to pages that describe the values and requirements as shown in Figure E - 13.

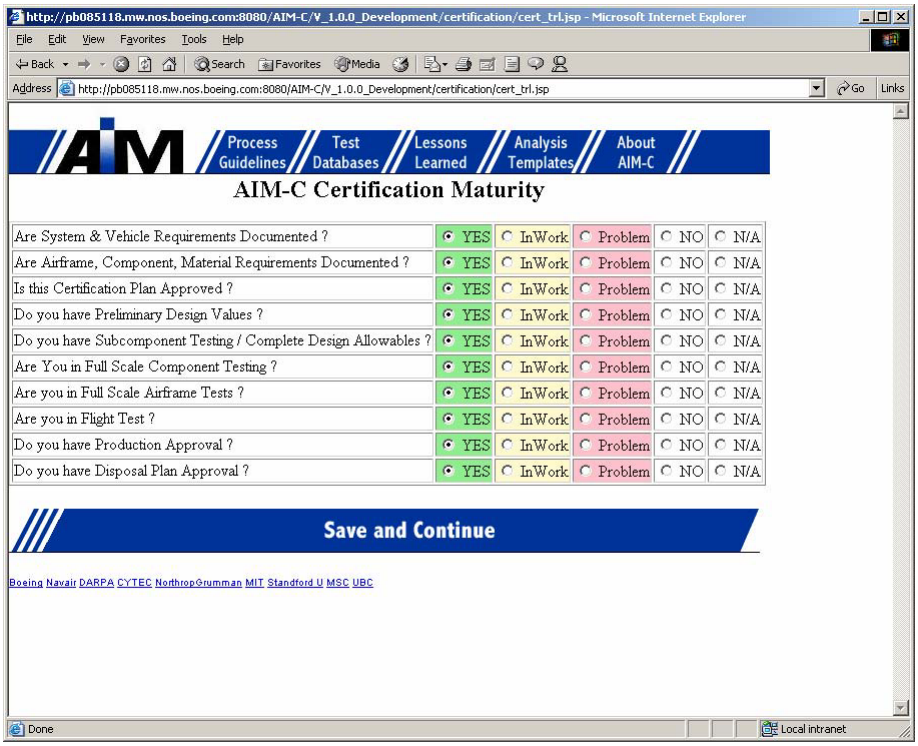


Figure E - 12. Certification Maturity Chart

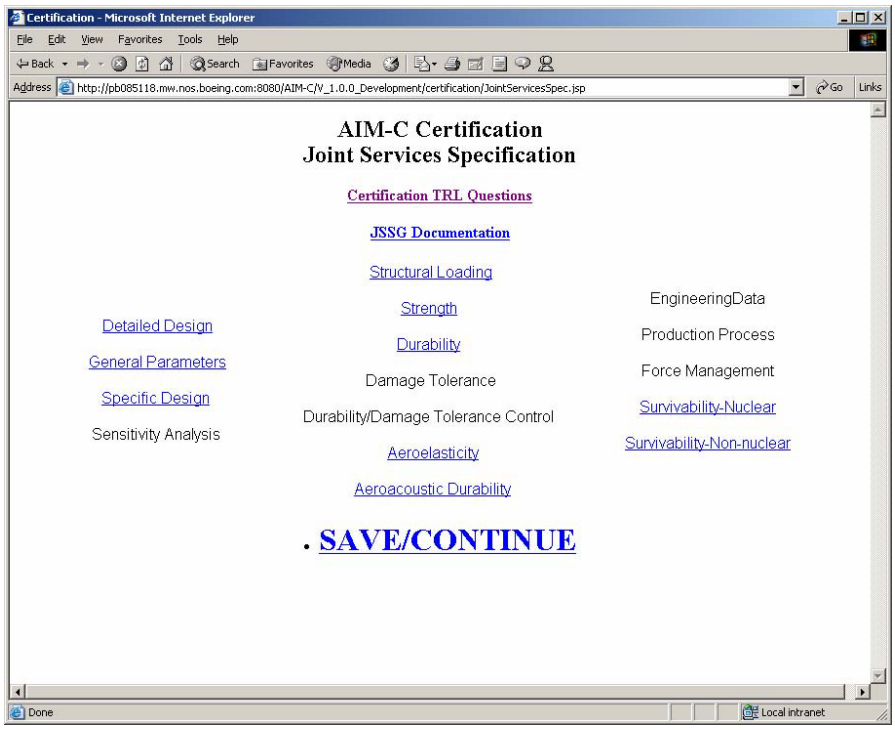


Figure E - 13. Certification - Joint Services Specifications

Some of the pages include detailed design, general parameters, specific design, loading, strength, durability, aero-elasticity, aero-acoustic durability, and survivability. Each of these is a link to pages below it that clarify the inputs. The general parameters link has the most information, so its detailed menus are described below.

In the general parameters sections, there are a series of pages which include airframe configurations, limit, ultimate, and design load factors, lightning strike/electrostatic charge, equipment, deformations, foreign object damage, payloads, service life and usage, producibility, weight distributions, atmosphere, maintainability, weights, chemical, thermal, and climatic environments, supportability, center of gravity, power/thrust loads, lateral center of gravity position, flight control and stability augmentation devices, replaceability/interchageability, speed, material and process, cost effective design, altitudes, finishes, flight load factors, non-structural coatings, films, and layers, land based and ship based aircraft ground loading parameters, and system failures.

2.9 Durability

The Durability section of the software is quite detailed. There are a series of steps that should be followed which includes a checklist, a library, guidelines, and interpretation. A picture of the first Durability pages is shown in Figure E - 14. This page shows a series of links that will display the steps, as well as the durability methodology, and links to the durability readiness level sheets.

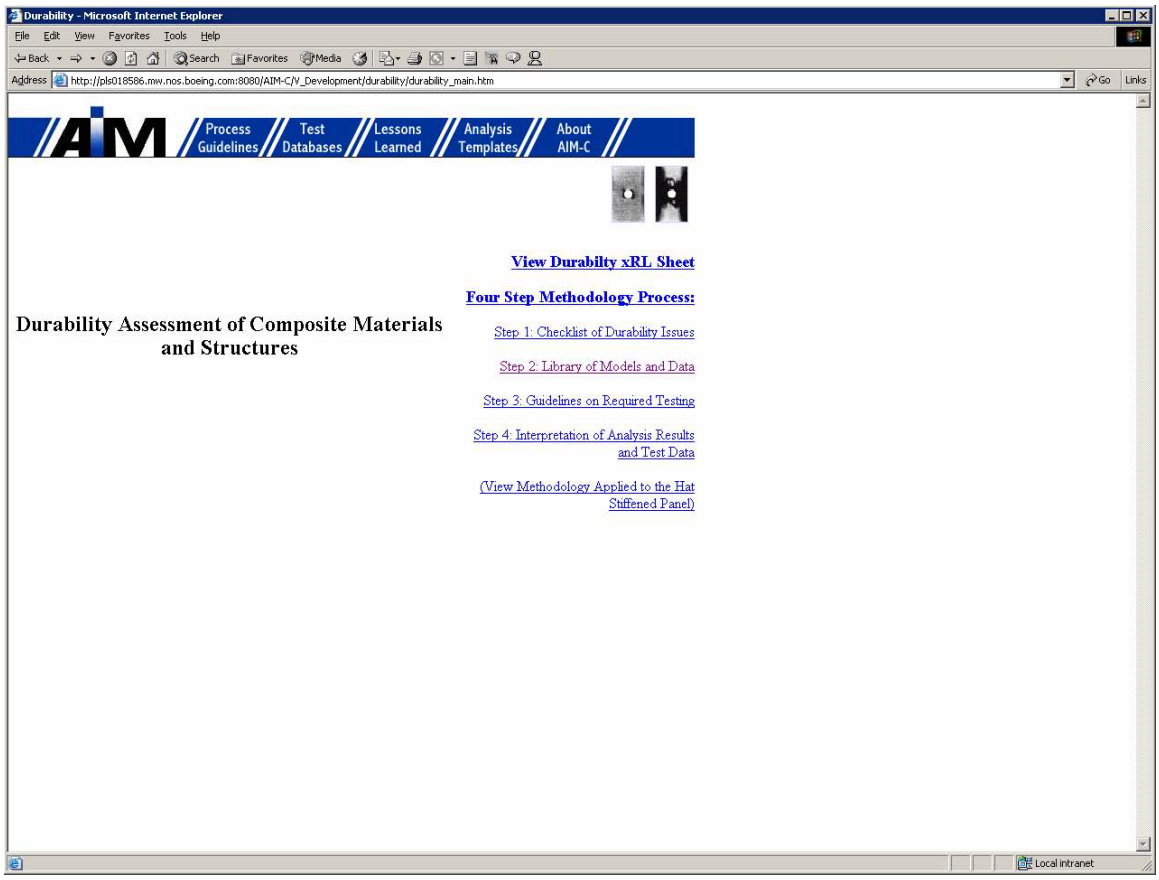


Figure E - 14. Durability Pages

The durability library has all the models and spreadsheet to download. Each of these has a description with the download to explain what that code includes. A sample picture of this is in Figure E - 15. On this page, many downloads are available such as Integrated SuperMicMac and DuraSoft Download, Thermal Degradation SpreadSheet, Degradation Theory Manual, Thermal Degradation Data Set, SuperMicMac SpreadSheets and Manuals (Stanford University), Delamination Tool Spreadsheet (MIT), Delamination Tool Manual, DURASOFT Download (MIT), DURASOFT Manual (MIT), and MicroCracking Data Set.

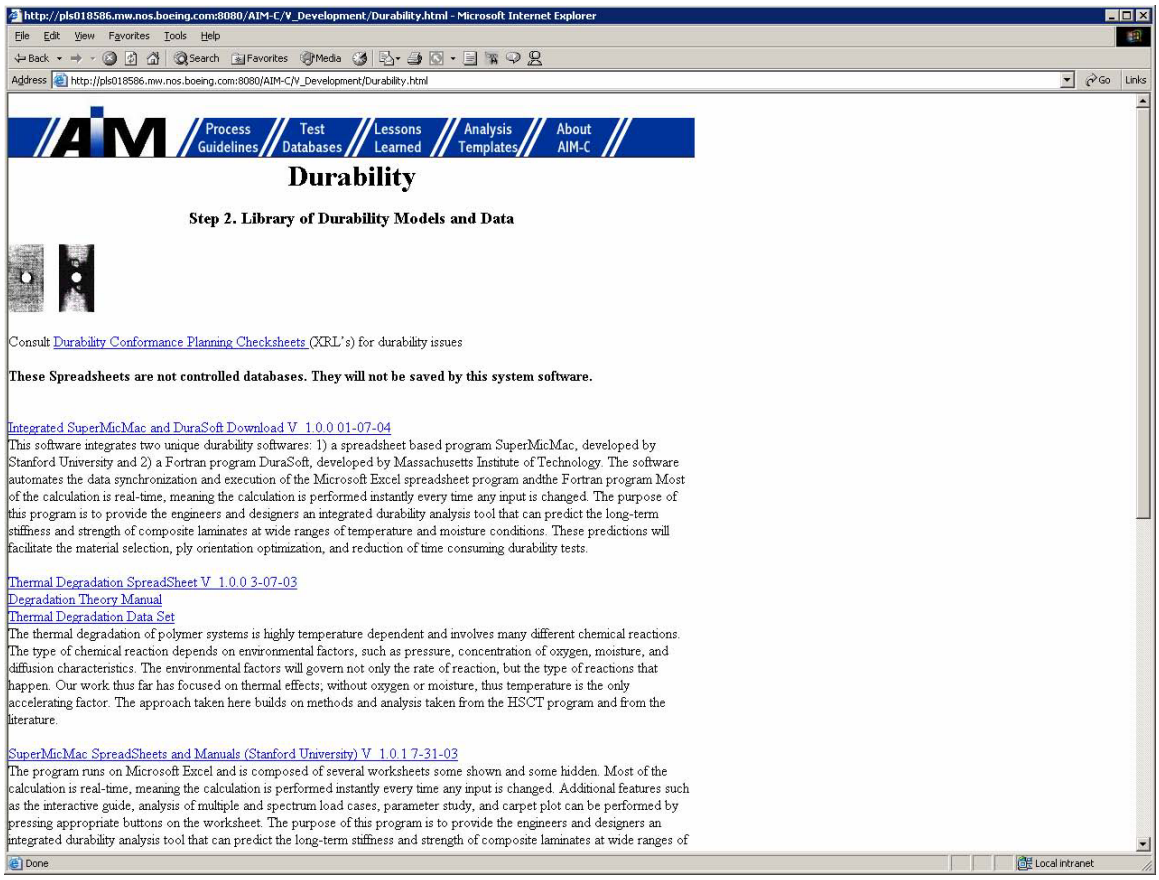


Figure E - 15. Durability Library

2.10 Design and Others

The Design maturity chart is very similar to the other maturity charts. It feeds the TRL chart. An example of this is Figure E - 16.

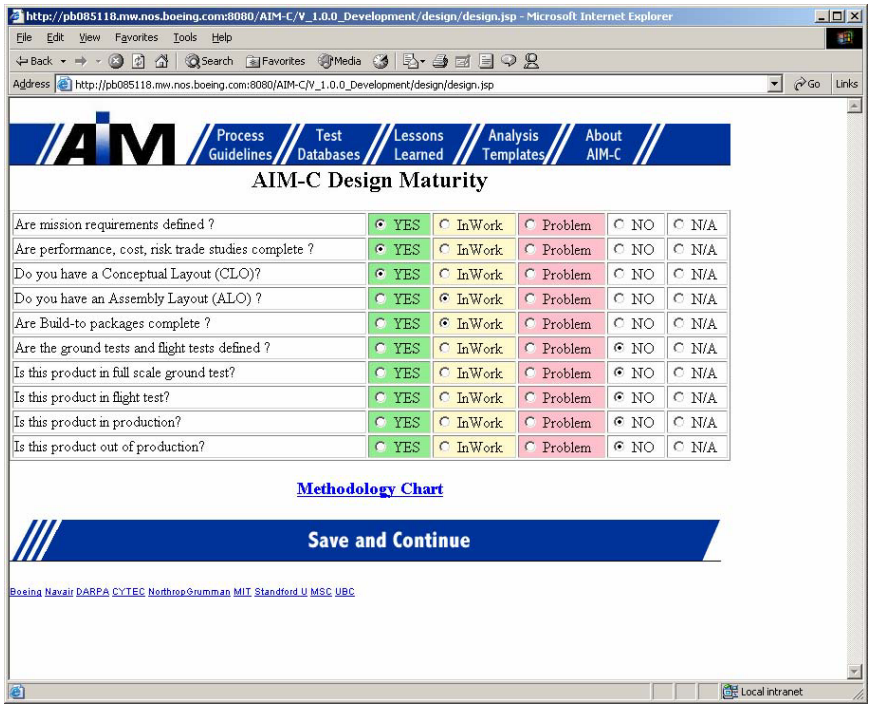


Figure E - 16. Design Maturity Chart

Maturity Questions exist for every topic in the TRL chart. The topics include Application, Certification, Design, Assembly, Structures, Fabrication, Cost, Supportability, and Intellectual Rights. These should all be answered to find out the location of the maturity level. The first few links under the TRL chart ask important questions for a starting point in the categories readiness level.

Each of these topics represents a line on the TRL chart and should be colored appropriately.

2.11 AIM-C Participants

All of the major participants have links to their websites on the participants page (Figure E - 17). This is a way for the team to find out more information about each other.

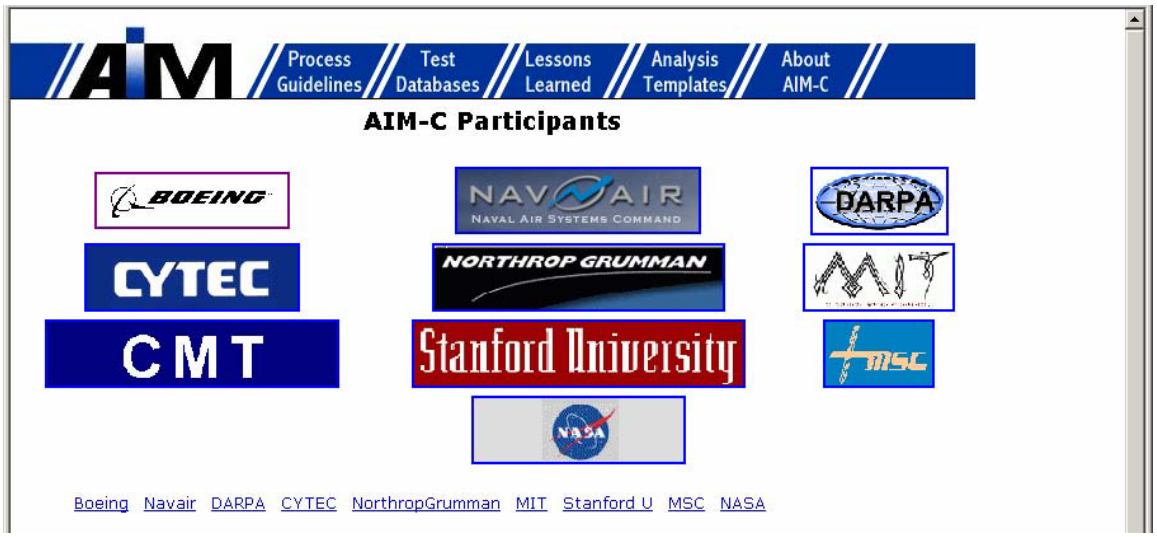


Figure E - 17. Participants

2.12 Readiness Levels through Worksheets

When starting in a new project, the default readiness level will default to one. As the user starts to fill out the data, the readiness level will increase according to the project and the required data needed to move on. There are ten different readiness levels that are tracked in the AIM-C system. They are Application, Certification, Design, Assembly, Structures, Materials, Fabrication, Cost, Support, and Intellectual Rights. Each of these categories are tracked and will color the readiness level chart with the correct information on if the process is complete, in-work, not done, not applicable, or if there is a problem in the process. They are designated by the color green if complete, red if there is a problem, and yellow if there it is in-work. White colors indicate it is not done or not applicable. The chart that shows all of this is called the Technology Readiness Level (TRL) Chart, which can be seen in Figure E - 18. It clearly shows where a major category is falling behind on its way through the maturity of the product. The color-coding on the TRL chart indicates which topics are falling behind as the insertion process progresses. Each of the "****" symbols in the colored boxes is a hyperlink to the data represented behind that box.

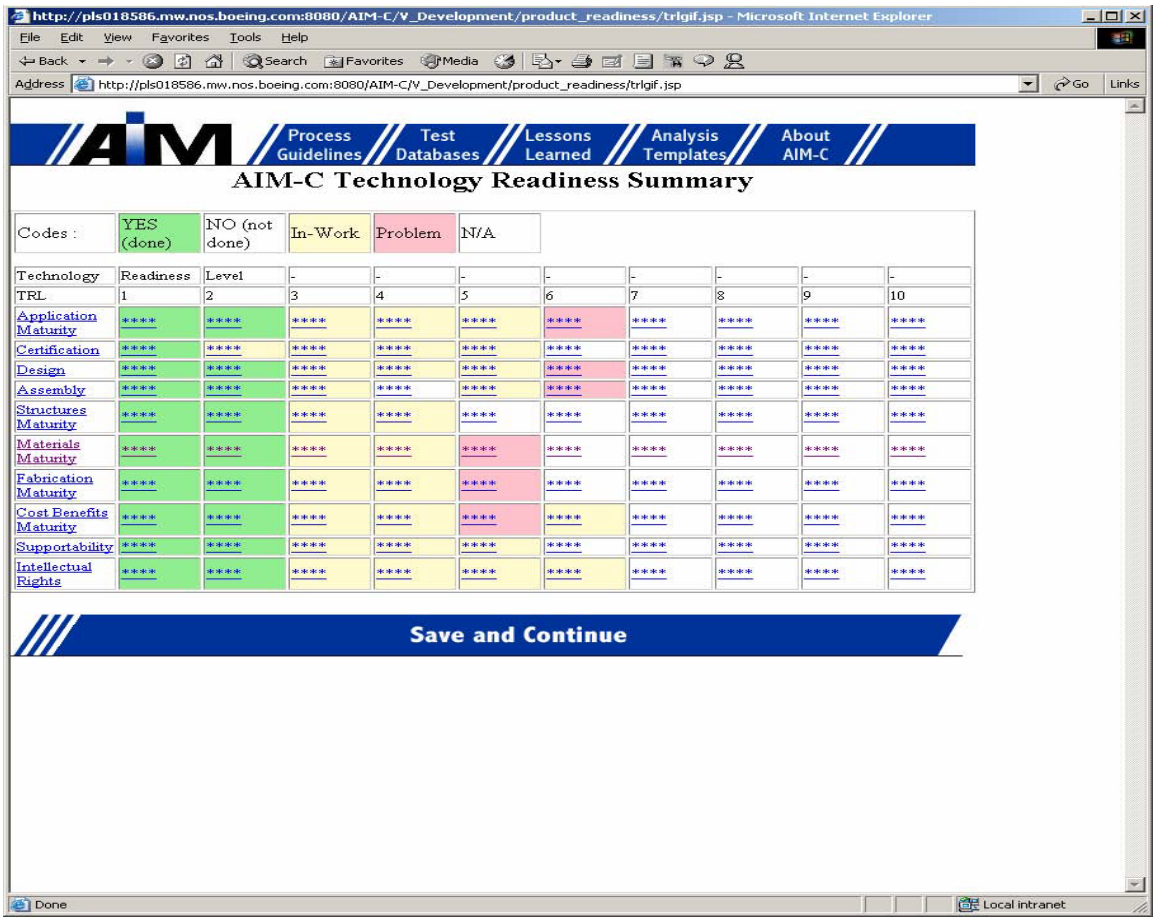


Figure E - 18. Technology Readiness Level Chart

Some of the categories such as Materials can be tracked on a more detailed scale. Material is divided into four sub-categories called Resin and Adhesive, Fiber, and Prepreg. If there is a problem in any one of these subcategories, the Materials readiness level cannot increase unless the problem has been resolved. Some examples of these can be seen in Figure E - 19.

Each of the subcategories will bring the user to a page that contains test details, lists of properties, and their priority. These details can be further broken down into worksheet pages where the property is described and a pedigree is attached to it. Some of the information that is captured consists of approach used to gather data (test, analysis, combined approach, previous data, or heuristics), specifics about the data, assessment of the data, date this was gathered, design value, mean, units, standard deviation, norm-mean, uncertainty, minimum, maximum, notes, pedigree, comments, xRL rating for data, completeness, and if the data should be locked. All of this information is used to assess the level where the material system is. This information is collected for each property on each of the 5 readiness levels specified to complete the insertion process.

After a few of these readiness level charts are filled in, the user has the opportunity to choose which of the data is the best representation and place that data into the details

page. This is the link on the far right side of the xRL sheet. This means that if one of the readiness levels was better than another, for instance, test is better that analysis, then the proper data from the test can be loaded into the details page.

Ideally, that property would be defined by the user and stored in the details page, so that the best data would be used from the details page independent of what level that property had data for.

2.13 Technology Readiness Level

The next step in the process is to start with the Technology Readiness Level. The user can get there by going to the Process Guidelines, Technology maturity, Edit TRL tab on the main menu or on the upper left of the home page. This will pop up the Technology Readiness Level chart. These are color coded so the user will have an idea what areas in the process need attention. The colors of this page are as follows. If everything is complete or in good status, the boxes will be green. If the box is currently in work, the box is yellow. If the box is red, a problem has been found and needs to be resolved before moving on to the next step. A white box indicates that the box still lies in the future or is not applicable. Initially, most of the boxes will default to white. Some logical rules have been applied to this page. For instance, if a box in the same column as a red box is green, the program will automatically change it a yellow box. If a green box lies down stream (to the right) of a red box, the green box will turn yellow. This is done so that the user knows he or she is no better than the red readiness level for any category. See Figure E - 18, for an example. The first box that has a problem must be resolved before the readiness level of this system can increase.

Maturity Questions exist for every topic in the TRL chart. The topics include Application, Certification, Design, Assembly, Structures, Fabrication, Cost, Supportability, and Intellectual Rights. These should all be answered to find out the location of the maturity level. The first few links under the TRL chart ask important questions for a starting point in the categories readiness level.

2.14 Readiness Levels Through Worksheets

The readiness level is calculated by how far along the material properties have been tested in the system. For instance a readiness level of zero would correspond with no tests or analysis performed to get good data for that property. If this test must be done and approved to move to a readiness level of 1, then that aspect must be worked to move the readiness level up.

For materials readiness, there are four sub-levels that feed the TRL chart. These levels are resin, fiber, prepreg, and adhesive. In the methodology process, these are the first charts showing XRL levels. If you click on one of these pages, the GUI will display a readiness level chart as illustrated in Figure E - 19 that gives the user the category for that item. There are a list of links on the materials page that lead the user to properties and characteristics.

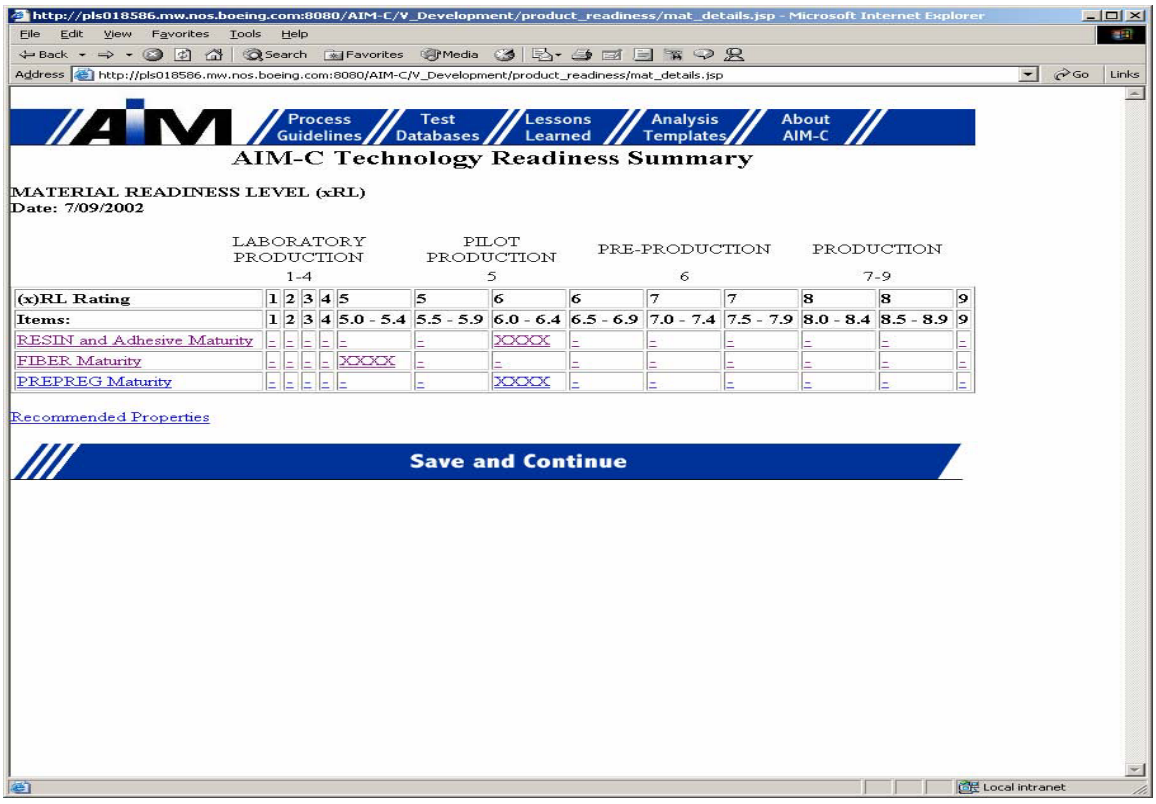


Figure E - 19. Material Readiness Level Chart

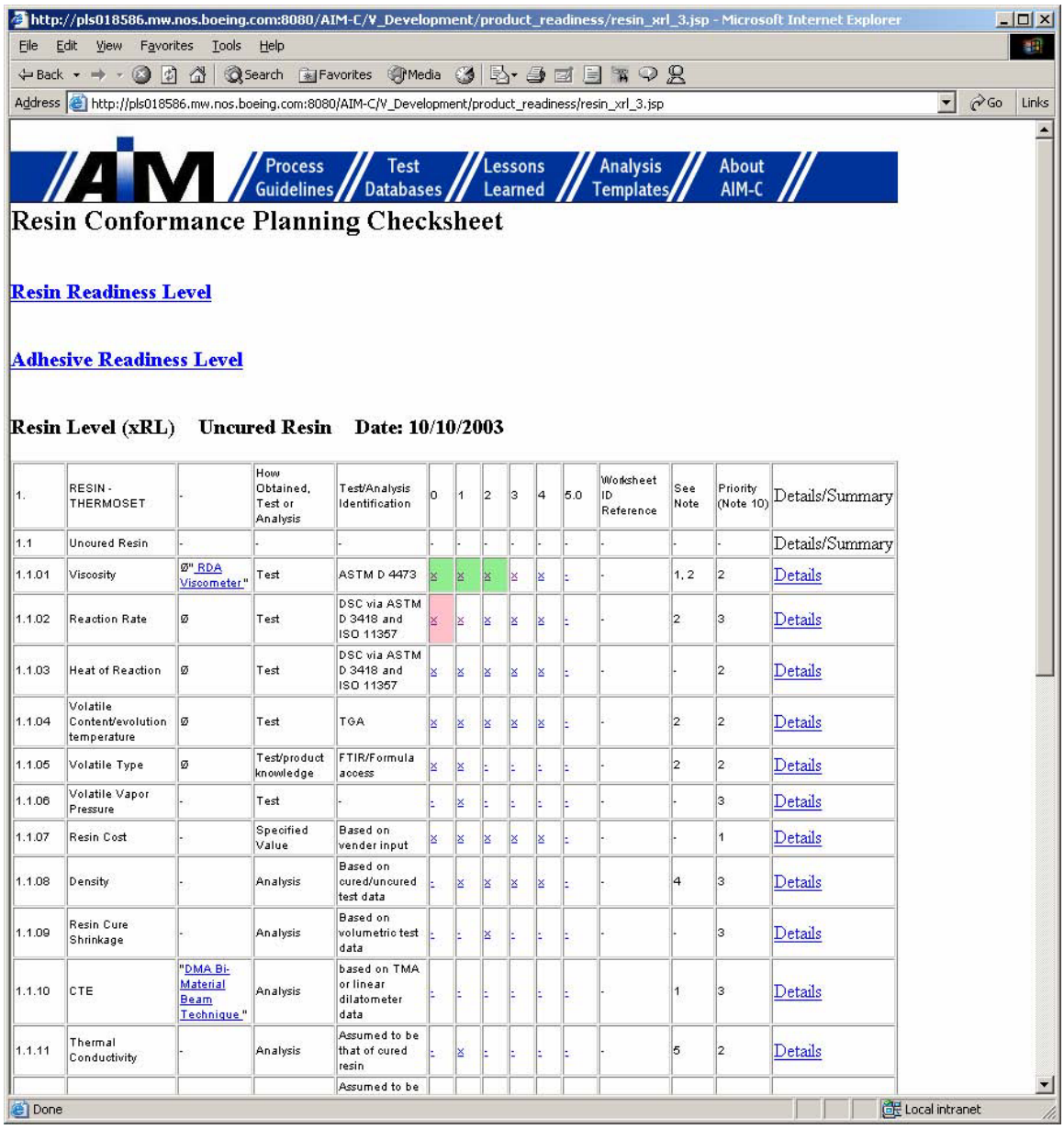
Each property is assigned a readiness level because some properties are important early in the insertion process and others are not. Many properties must be derived from multiple tests to get a good approximation of what that data should be. Some properties are time, temperature, or pressure dependant that requires curves to calculate. At this time, there is not a capability to incorporate these kinds of changing properties.

Overall, the readiness levels track how advanced a material is. This is assuming the user will start at a component level such as fiber and resin. They will then have to work up to the prepreg, lamina, laminate, and finally up to the structure level.

To start, the user can click on the resin can on the home page. This will lead them directly to the resin Conformance Planning Checksheet (Figure E - 20). At this time, the user should start at the first level of 0 and fill in all the properties they have. To do this, the user should simply click in the row they want to start and click on the appropriate readiness level number. This will lead them to a worksheet page (Figure E - 21 and Figure E - 22) to different approaches.

There are a total of ten approaches to use for each property. Filling in all the boxes will allow the user to capture as much data as they can for each property. When all the boxes are filled in on the worksheet page, the user can move back to the XRL sheet by pressing the Save/Continue button. If they wish in input all the detailed info, they will press the approach number and fill in the information. This process of inputting data should

continue until all the known data is in the database system. Continue through the resin, fiber, prepreg, lamina, laminate, and structures XRL sheets.



1.	RESIN - THERMOSET	-	How Obtained, Test or Analysis	Test/Analysis Identification	0	1	2	3	4	5.0	Worksheet ID Reference	See Note	Priority (Note 10)	Details/Summary
1.1	Uncured Resin	-	-	-	-	-	-	-	-	-	-	-	-	Details/Summary
1.1.01	Viscosity	Ø" RDA Viscometer"	Test	ASTM D 4473	x	x	x	x	x	-	-	1, 2	2	Details
1.1.02	Reaction Rate	Ø	Test	DSC via ASTM D 3418 and ISO 11357	x	x	x	x	x	-	-	2	3	Details
1.1.03	Heat of Reaction	Ø	Test	DSC via ASTM D 3418 and ISO 11357	x	x	x	x	x	-	-	-	2	Details
1.1.04	Volatile Content/evolution temperature	Ø	Test	TGA	x	x	x	x	x	-	-	2	2	Details
1.1.05	Volatile Type	Ø	Test/product knowledge	FTIR/Formula access	x	x	-	-	-	-	-	2	2	Details
1.1.06	Volatile Vapor Pressure	-	Test	-	-	x	-	-	-	-	-	-	3	Details
1.1.07	Resin Cost	-	Specified Value	Based on vender input	x	x	x	x	x	-	-	-	1	Details
1.1.08	Density	-	Analysis	Based on cured/uncured test data	-	x	x	x	x	-	-	4	3	Details
1.1.09	Resin Cure Shrinkage	-	Analysis	Based on volumetric test data	-	-	x	-	-	-	-	-	3	Details
1.1.10	CTE	"DMA Bi-Material Beam Technique"	Analysis	based on TMA or linear dilatometer data	-	-	-	-	-	-	-	1	3	Details
1.1.11	Thermal Conductivity	-	Analysis	Assumed to be that of cured resin	-	x	-	-	-	-	-	5	2	Details
				Assumed to be										

Figure E - 20. Resin Technology Readiness Level Chart

Each of the approaches will bring the user to a page that contains test details, lists of properties, and their priority. These details can be further broken down into worksheet summary pages where the property is described and a pedigree is attached to it. Some of the information that is captured consists of approach used to gather data (test, analysis, combined approach, previous data, or heuristics), specifics about the data, assessment of the data, date this was gathered, design value, mean, units, standard deviation, norm-mean, uncertainty, minimum, maximum, notes, pedigree, comments, xRL rating for data,

completeness, and if the data should be locked. All of this information is used to assess the level where the material system is. This information is collected for each property on each of the 5 readiness levels specified to complete the insertion process.

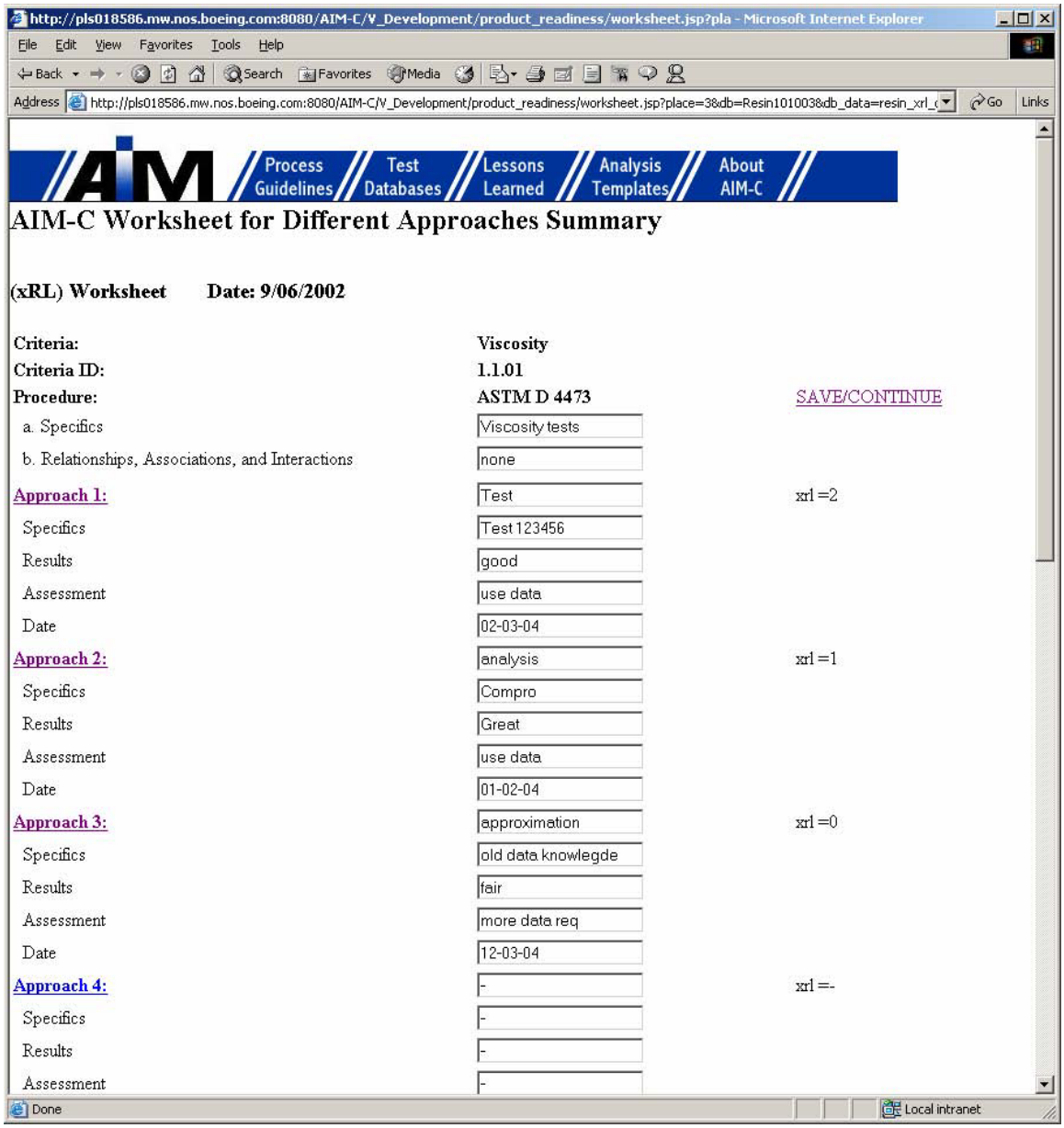


Figure E - 21. Worksheet for Approaches

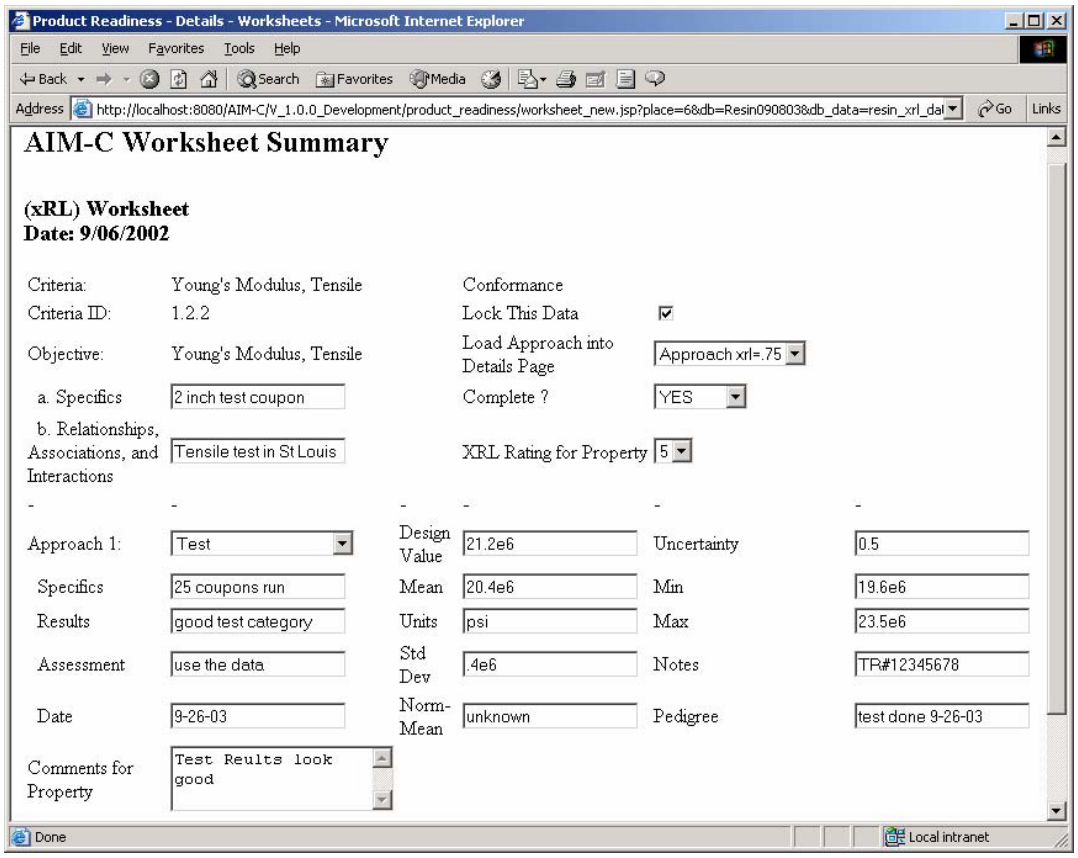


Figure E - 22. Worksheet Summary Page

At the time of AIM-C Phase 1 software delivery detailed worksheets exist for resin, fiber, prepreg, lamina, laminate, durability, and processing-producibility. These pages will need to be modified when properties include time or temperature dependencies. For the initial GUI, simple values were used as placeholders for more information as it becomes available.

After adding data to the system, the user may choose to run some of the templates to get more of the properties by analysis.

2.15 Templates

The templates are designed for the user to be able to quickly solve an analysis problem involving the insertion of materials on a new product. Many of the templates were set up for standard analysis methods such as an open-hole tests, a cure cycle optimizations, and failure prediction by using RDCS.

Currently, to create this simple RDCS run, a number of different processes are involved. Initially, the input variables for each of the RDCS projects were mapped to the TRL and XRL detailed worksheets. These values are captured from the user database and transferred to the demo page. At this point the values can be modified before the RDCS run is started. The values are then placed in the RDCS batch file. The file is transferred through an MS Exceed session in the background. The batch file is run on a UNIX or

Linux machine, and the demo page displays the running status during that time. Once the job has completed, the results are returned to the GUI. These data points can then be placed back in the database for future use. The user is also able to view simple plots within the window. The team uses GNUPLOT for this simple process.

In order to set one of these templates up to run, the user must go to the templates page and choose a template. Picking on the title or the picture of the template can do this. A description of the template follows the picture in the lower right hand corner of the each template area.

The AIM-C system has many templates, which run a series of executable codes to solve a specific problem. This page can be seen in Figure E - 23. At the time of AIM-C Phase 1 software delivery they include Template 4 (Fiber, Resin, and Prepreg Modules to Calculate Prepreg Thickness), Template 9 (Cure cycle optimization), Template 10 (Carpet Plot Generator Using SIFT), Template 11 (Interply Delamination Defects), Template 12 (Producibility and Processing modules for evaluation of heat up rate capability and exotherm potential of Hat Stiffened Panel), Template 14 (Structural Design of a Hat Stiffened Panel Using a Parameterized Finite Element Model), Template 15 (Effects of SUBLAM model of the hat stiffened panel (HSP) with fracture responses), Template 16 (StressCheck Failure Analysis by Strain Invariant Method of Hat Stiffened Panel), Template 17 (Predicting uncertainty analysis of open hole tension (OHT) coupons), Template 21 (General analyses of laminated coupons), Template 22 (Failure Loads Distributions Based on SIFT Uncertainty), Template 23 (Strain Invariant Failure Theory - Initiation Analysis of a Flange Termination), and Template 24 (Angle Mesh for Processing to calculate Spring-in and Warpage). Each of these templates has descriptions associated with them. The templates are currently run on a Unix or Linux system that has an RDCS service. The executable codes inside the templates reside on the Unix or Linux side and they are called from the AIM-C system by a series of scripts that run after the user has placed all the input data in the appropriate boxes.

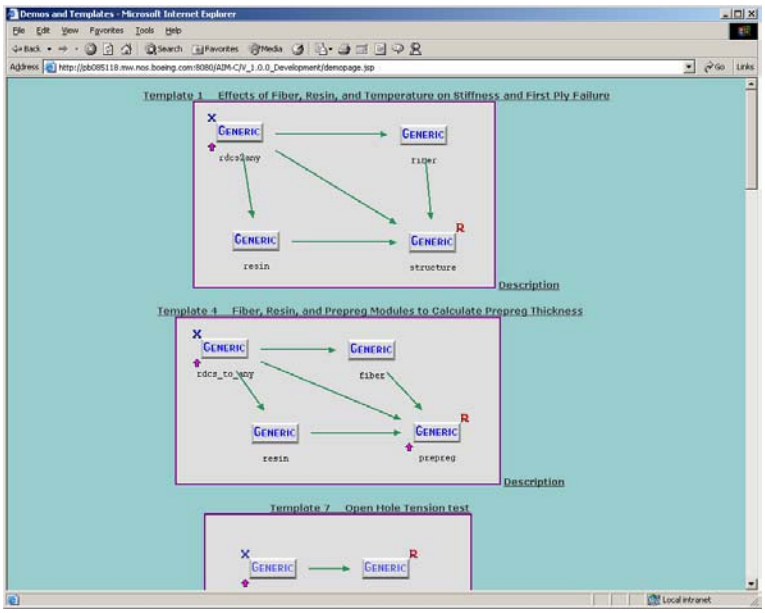


Figure E - 23. Template Screen

Once the user has chosen a template, a screen will come up that will allow the user to look at old runs from the view catalog button, define new inputs, view inputs, view outputs, see details, execute the template, or reset the status in the template. If this is the first time running the template, the user will have to go to the Define Input button. At this time, the template will ask for the variables that it needs to run templates. It will often present a range for the user, so that non-meaningful data is not used. Default values will populate the boxes, but the user can change the values inside.

There is a "Define Input" button at the top of the page that defines all of the inputs. If this is the first time running the template, the user will have to go to the Define Input button. This will display some information about the run, for example, the description, a default value, the units, and the range or domain that the data is valid in (Figure E - 24). The user must place a name in the Instance description box. This is how the user will designate this run from others in this project. The name should be descriptive and be followed by a date. At this time, the template will ask for the variables that it needs to run templates (Figure E - 24). It will often present a range for the user, so that non-meaningful data is not used. Default values will populate the boxes, but the user can change the values inside. After the user is happy with the data, they then either proceed to the second page of inputs or are ready to execute the template. From the last input page, they should press the "Continue" button on the bottom of the screen. The data is then registered and stored in the system. The "Execute" button on the top of the header should be chosen to send the job running on the Unix or Linux side and start the analysis. Once this button is pushed, the scripts send information in the form of RDCS batch files and XML files to the Unix or Linux side.

There is a status button on the demo input screen that tells the user the status of the project. During the definition of the input the status button will say "Being Defined". It

will say “Running” if a process is running on the Unix or Linux side. When the results return, the status will change to “Complete”. Occasionally if there is some interruption in the connection between the PC and the Unix or Linux box, the process may die for no explained reason. At this time, the user may need to reset the status button when the job has failed (either on the Unix side or on the PC side).

The status will change to running and the results will return after the job has finished. The status window will update approximately every 5 seconds. During the run, the user can browse the AIM-C GUI, enter new data in the system, but they cannot run another template while one is executing. If they leave this page and return, the status should return to the state of the job. Once it says “Complete”, the user may view the results by “Viewing Output”. The results should show up.

After the RDCS run has completed, the results are returned to the AIM-C system and are captured in the file system. These results can be viewed at a later time by going into the catalog for each of the templates. In some cases plots are viewed (Figure E - 25), but in most cases, the results are returned in the form of a CSV data file that will open up in MS Excel.

If the user wants to check old results to see if a similar run has been performed, they can click the “View Catalog” button and Define a target for a search. This will search for the information they are looking for. This will rate the previous results according to how close they match the search criteria.

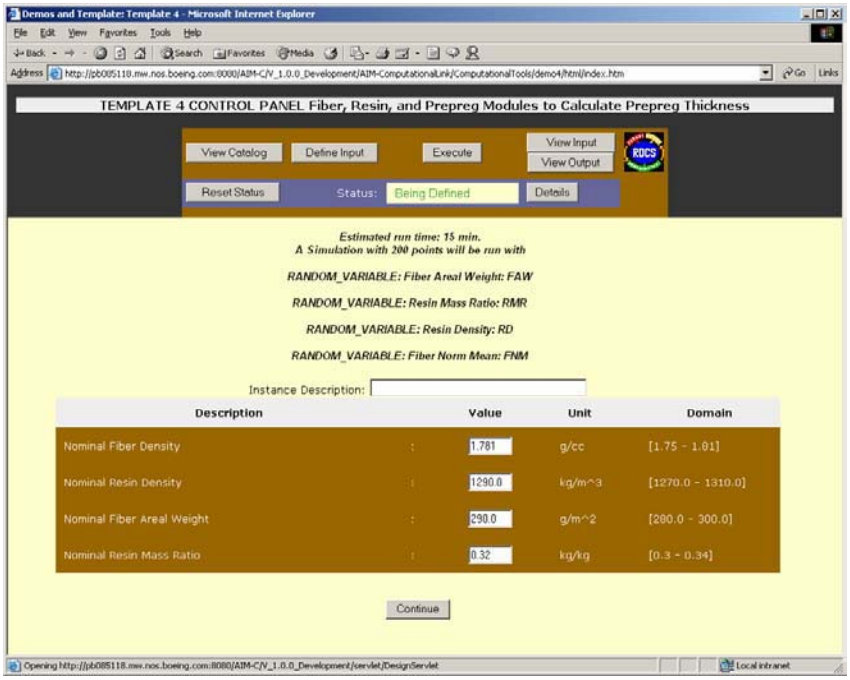


Figure E - 24. Example of a Template Input Screen

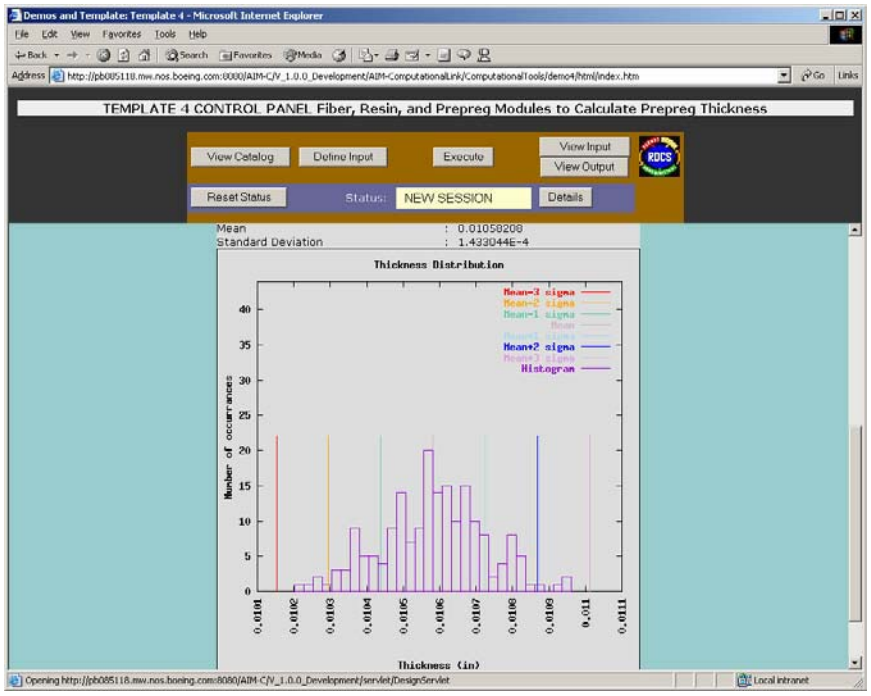


Figure E - 25. Example of a Template Output Screen

2.16 Modules

Modules are spreadsheets, executables, or the components that make up the templates. Some of these codes are licensed, some are proprietary, and some are made specifically for the AIM-C program. Each is listed according to the version number and the date it was added to the system after configuration control release (Figure E - 26). All of this software is downloadable so the user can install it on their computer and run. Keep in mind that StressCheck is a licensed product, so it will not run unless there is a license available. Each of these has a brief description underneath the hyperlinks. At the time of AIM-C Phase 1 software delivery the modules available for download are:

Compman V1.1.4 1-27-04 (Boeing Proprietary Software)
Cost Spreadsheet (Boeing) V_1.0.0 9-03-03
Delamination Tool Spreadsheet (MIT) V_1.1.0 9-01-03
DURASOFT Download (MIT) V_2.0.0 11-07-03 and V_3.0.0 2-9-04
Fabric V1.0.0 6-9-03
Fiber V1.0.0 5-12-03
Integrated Durability Download V_1.0.0 1-07-04
ISAAC V1.0.0 7-15-03
Lamina V1.0.0 5-20-03
Laminate V1.3.0 10-6-03
Laminate V1.4.0 02-16-04
MicroMechanics SpreadSheet V_1.0.1 7-31-03
Prepreg V1.0.0 7-10-03
Processing V3.1.3 5-29-03
RDCS2File V1.0.0 5-20-03
Resin and Adhesive V1.0.0 5-19-03
ResinMan V1.0.0 6-20-03
StressCheck 6.2.1 h 1-27-04
SuperMicMac SpreadSheet V_1.0.1 7-31-03

Thermal Degradation SpreadSheet V_1.0.0 3-07-03
Uncertainty Analysis of Coupon Tests V_1.0.0 02-16-04
WinASCOM Public Version 1.0 7-3-03

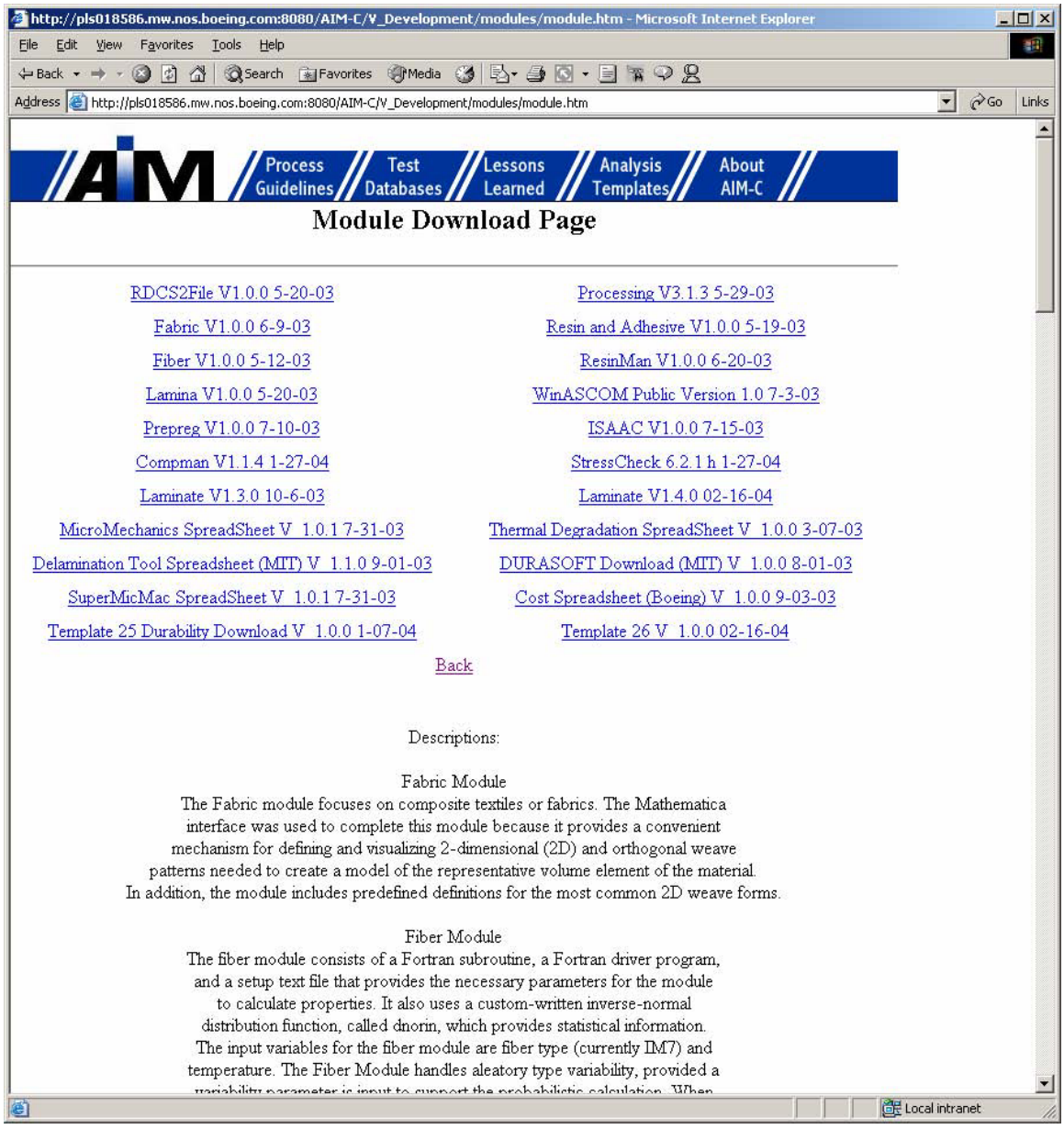


Figure E - 26. Example of Module Download Page

Another feature provided through the AIM-C System is the SEER Cost models developed by Galorath, the use of which requires a license. This is a cost prediction program that can calculate recurring costs. Since this is an application that Microsoft does not recognize, the mime-types have to be set for the correct file/application connection to be made in order for the SEER application to appear when clicked from the GUI. One drawback of this application in the GUI is that the SEER application executable must be resident on the users computer in order for it to work. This is a licensed product, so it

will only run if the user has a valid license file. A sample screen shot is shown in Figure E - 27. SEER-H has the capability to perform non-recurring cost analysis.

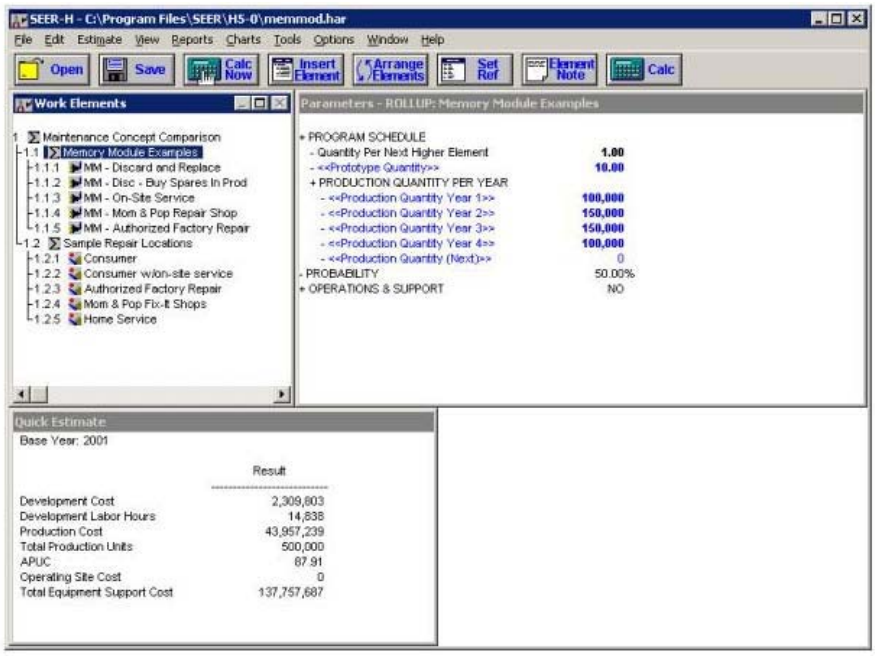


Figure E - 27. SEER Cost Model Screen

The Producibility Module is another part of the AIM-C system. An example of this can be seen on Figure E - 28. This module will help the user on many aspects regarding the production of parts. For instance, there are many pages that ask for information on cutting, layup, debulking, cure, bagging, tooling, and non-destructive evaluation. These procedures are defined and explained in a series of documents and presentations inside the producibility module. This module produces calculations on material per ply thickness, design nominal thickness, material average calculated thickness, material standard deviation thickness, material standard deviation minimum, material standard deviation maximum, material specification limit minimum, material specification limit maximum. These calculations will assist the user in determining if the part will be thick or thin enough for its desired use. This module also has data on voids, delaminations, porosity, inclusions, features, and distortions.

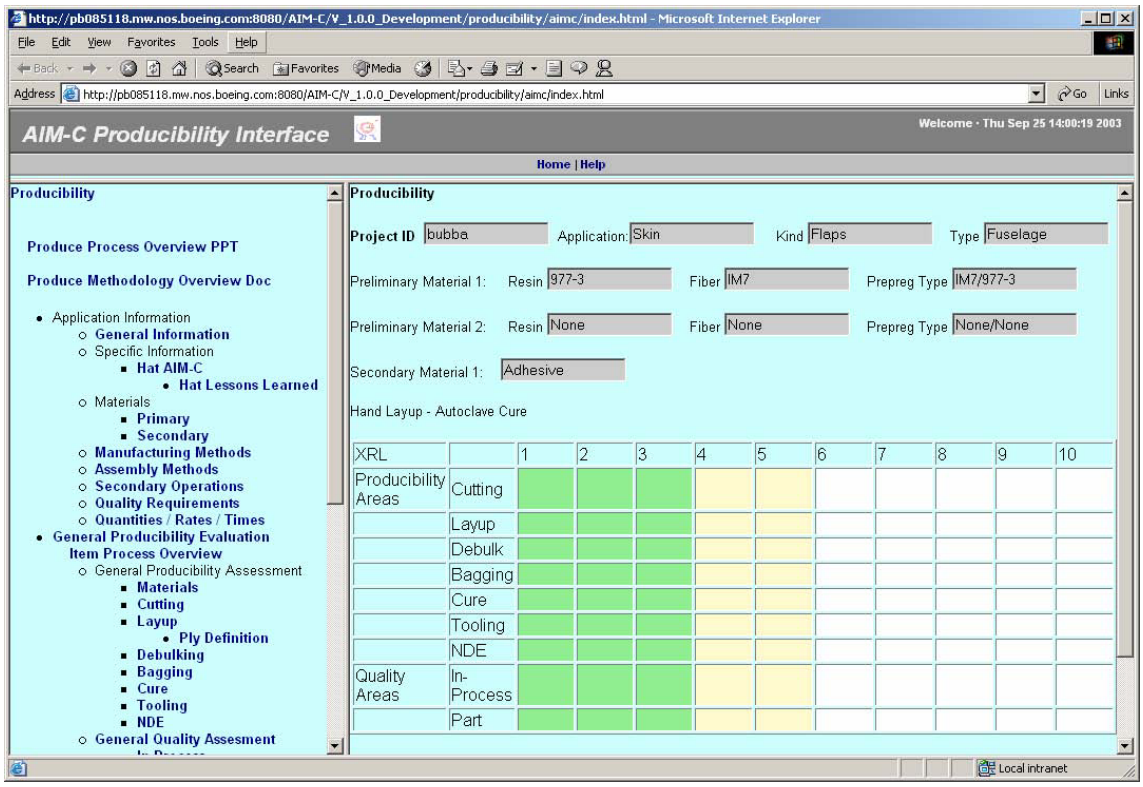


Figure E - 28. Producibility Module Page

2.17 Utilities

AIM-C has a few utilities that make the system work a little bit better. Some of these include the scripts such as an RDCS-to-file script that is used by RDCS to quickly transfer variable data into the RDCS run. It is used mostly on the Unix or Linux side and makes running RDCS a bit easier for the user. In most cases, the general user does not run this standalone.

The current utilities are only used if the user wants to run RDCS standalone. There is one script that is an RDCS_to_Any script that transforms parameterized data files into RDCS input files.

2.18 Third Party Software

AIM-C has many third party software providers. These occur on every level of the tree that makes up the AIM-C system.

For instance, on the application tier, there are codes that run behind the scenes in the software. These include Java2 Standard Development kit (J2SDK), Java Expression Parser (JEP), and Python (a scripting language).

On the web tier where the server resides, AIM-C uses COS-com.oreily.servlet, Java2 Standard Development kit (J2SDK), Java Expression Parser (JEP), WebEE (Boeing code) and Tomcat Server Engine. For Version Tracking utilities, the AIM-C system uses WinCVS and WinMerge. Microsoft Access 2000 must be installed on the server.

On the Unix side, there are many programs in the background that run strength analysis codes. They include Patran, Nastran, Compro, Ansys, Abaqus, StressCheck, RDCS, and Compman.

On the client tier or where the browser resides, there are three executables that need to be installed. These include Java SDK, Java3D for visualization, Cost Module (SEER), and Product Life Cycle Process Database (PLCP). It is assumed that the user will have Internet Explorer 6.0 installed on their machine.

Some of these can be downloaded from the following places:
•Uses Jakarta-Tomcat 4.1.24 as a server engine
Found at www.apache.org (freeware)
• Uses M.S. Access 2000 Database to store data
• Runs Java codes through JDK 1.3.1_06
Found at www.java.sun.com (freeware)
• Runs Java 3-D for images
Found at www.java.sun.com (freeware)
• Runs on MS Internet Explorer 6.0
• Uses RDCS for analysis means
• Includes Documents, Excel Files, and Powerpoints
• Runs on MS Access 2000

2.19 MS Access Database

The database used for the Alpha System is a Microsoft Access 2000 Database. The following information talks about the structure of the database. The general user will not need to know this information. The database administrator is the only one who will be able to see this data.

There are over 100 tables in the database. Each of these tables references a specific set of data. Many of these tables are non-changing static data. There are over 25 tables that change depending on user inputs and analysis. These are differentiated by a column named “Project” in each of those tables. There are rows in these database tables associated for every project.

If a new project is created, a java code will execute to creates a new set of rows in the changing tables called out from the table_names table that will populate the changing tables with space for new inputs. Default information will also be added to these rows from the table called table_default_proj. This will set initial information to get started. If a project is copied or renamed, the tables are altered appropriately. If a project is deleted, the rows in all of the tables from that project are wiped out all together.

Most of the tables represent data from XRL (specific readiness level) sheets. For many of these sheets, there are a ‘_data’ and a ‘_data_wkst’ table that holds the data. The initial sheet is a spreadsheet of properties, how they were obtained, test analysis, sequence number, and readiness level. The ‘_data’ sheet contains values for the property, units, uncertainty, min, max, standard deviation, and notes associated with this value. The column names are represented by field and column number, which is the default for Access. They are all ordered by ID. The ‘_data_wkst’ lists different means of obtaining

the data. This may include test, analysis, combinations or those, or other means. There is also a notes column in this table. These can be found in the following tables: Durability, Fiber_interaction, mech_prop_lamina, mech_prop_lamina2, mech_prop_laminate, mech_prop_laminate2, prepreg, ProcProd, resin, and resin2. All of these tables have columns specific to each project.

Many of the xrl tables do not have other detailed data associated with them. These are Cure_xrl, Cutting_xrl, Debulk_xrl, designAllowables_xrl, Fab_Methods_xrl, Fab_Rel_Matl_xrl, Fab_xrl, Layup_xrl, Material_xrl, Structures_xrl2, Support_xrl, and Structures_xrl. These mostly describe the current state of the readiness level depending on the components inside. The column names are represented by field and column number, which is the default for Access. They are all ordered by ID.

Many of the other tables are designed for individual pages. For instance, the additional inputs table is referenced from the Additional Info button under the legacy information. It contains variable names, values, units, standard deviations, normal means, uncertainty, min, and max data. This is needed if RDCS needs more data than what the GUI requests.

A few of the tables are property data sets for existing composites materials. Some examples of these are the tables of AS4 and IM7 data. These are used only on the materials menus when a similar system is needed for reference. The values in these tables are loaded into the database if needed. The cure_recommend table is referenced from the producibility menus. These tables are ordered by ID, but have column names such as Props, neg65deg, pos75deg, pos250deg, Units, and comment. The cure_recommend has columns titles Step and value to designate each step in the cure cycle.

There are a few overlapping tables that contain info in other tables. They are Fiber_Interaction, Prepreg_Interaction, and resin interaction. They contain the same columns as in the regular xrl tables. These were created to capture the readiness level of each property in the table depending on your design. They are ordered by ID and contain Field1 and either Field2 or Field3 in most cases. These can be deleted out if the JSP are modified. The project-specific readiness levels for each property that goes along with the material are located in the interaction_data tables. These are ordered by ID and contain Field1 for the column values.

There are two very large tables that contain a large amount of data not related to xRLs. They are the user_info and text1 tables. The text1 table holds all the inputs for the pages in the GUI. This includes capturing all the user-defined inputs, text boxes, and pull-down menu options in the rest of the GUI. The user_info table is only designed to capture the responses from the user that relate to the producibility module. They were separated because there was an efficiency issue searching the long tables for specific data. Both of these tables have columns named Variable, Val, and Project. They are ordered by ID.

Some of the tables in the database were created as a part of the RDCS demo information. These include Demo1, Demo1: Geometry, and Demo1: Nomogram as well as Input,

Input:Geometry, and Input:Nonogram. They list the project name, inputs, and outputs from the RDCS run.

Many of the tables were originally created by Northrop Grumman as part of the Producibility module. These include BackingPaper, Faw, Fiber, FiberDens, FiberForm, FiberKind, FiberType, FiberYield, Indirect Material, Part, Paw, Raw, Rc, Resin Type, ResinKind, Separator Material, Spool Material, Spool Requirements, TestMethod, Viscosity Model, X-Sectional area. Many of the tables have relationship involved. A picture of this is shown in Figure E - 29.

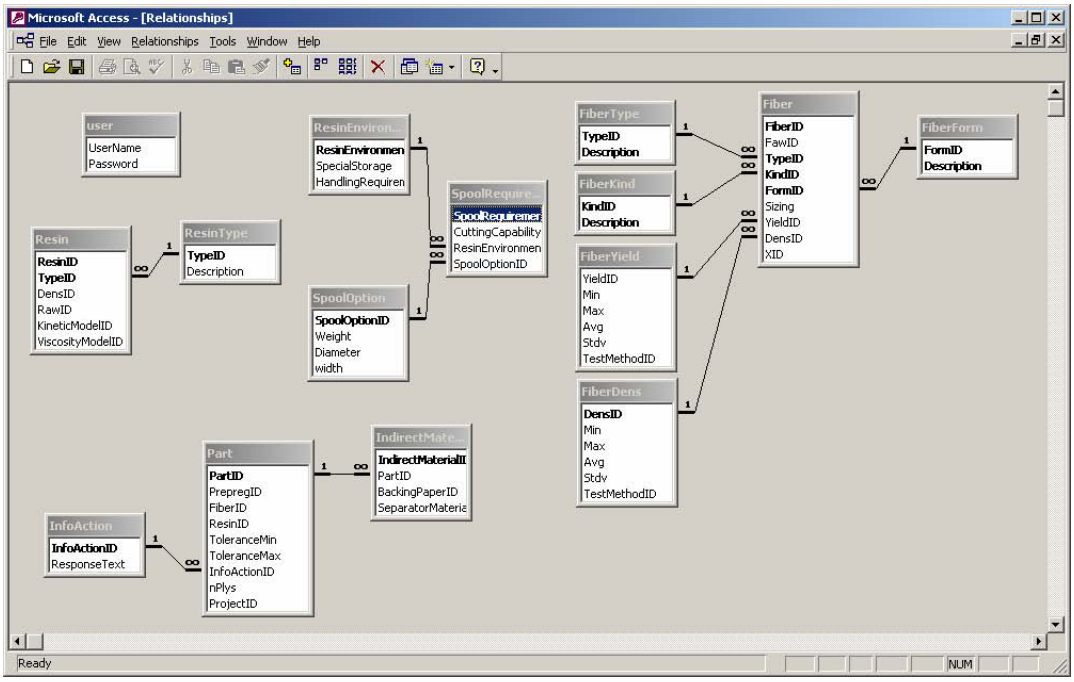


Figure E - 29. View of Database Relationship Structure

Tables that were all xrl tables (nonchangingdata) include applications_xrl, Cure_xrl, cutting_xrl, debulk_xrl, DesignAllowables_xrl, Fab_methods_xrl, Fab_Rel_Matl_xrl, Fab_xrl, Layup_xrl, Material_xrl, Resin_xrl_1, Structures_xrl2, Support_xrl, and Structure_xrl.

Tables that had no information include cutting_capability, Indirectmaterial, Input, ResinEnvirnmentRequirements, SeparatorMaterial, SpoolOption, and SpoolRequirements.

A sample view of the database table structure look like Figure E - 30, but this is changing all the time depending on new additions to the system.

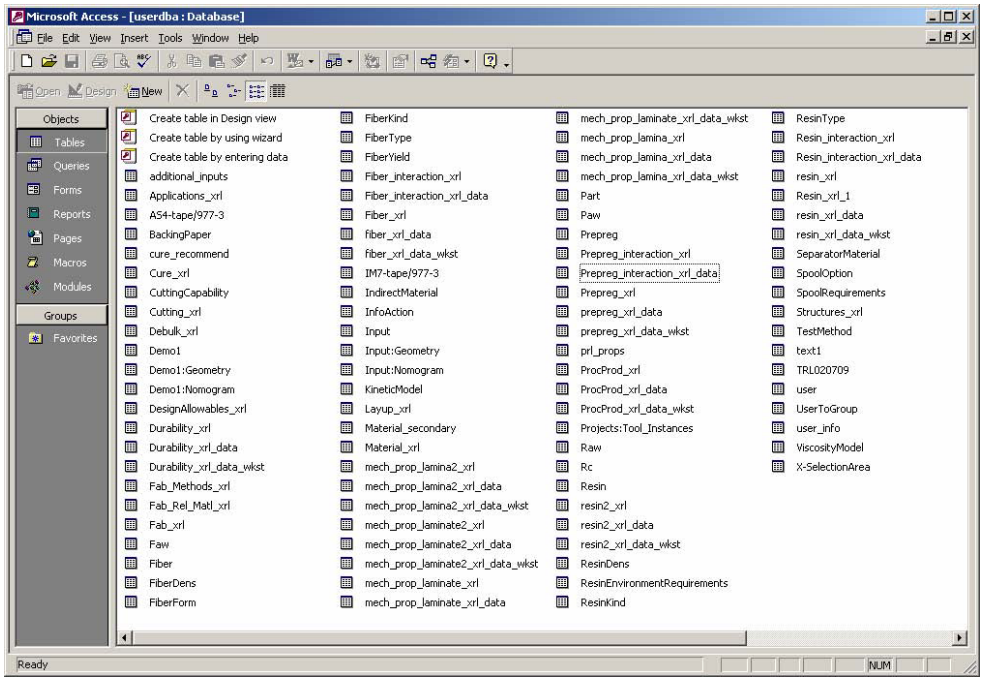


Figure E - 30. Database Table View

To the general user, the MS Access database acts like an information storage place. It will hold all the text input that the user is asked to put in. Since the information in the database is stored based on project name, the user should be careful to create a project name that is intuitive.

2.20 User Database

The user database is all the information that the user needs in order to travel through the insertion process. This information starts at the application definition and continues through testing and production.

Some of the initial data is already stored in the database. This includes data from IM7/977-3 and AS4/977-3. This data can be looked at if the user goes to the Test Database button on the top menu (Figure E - 31). Sample data 12K IM7 Fiber Property Validation Data, IM7 Fiber Specific Heat Validation Data, IM7 Fiber Thermal Conductivity Validation Data, IM7 Lamina Thermal Conductivity Data, IM7 Lamina Transverse Modulus Data, 977-3 Modulus Data, 977-3 Relative Exp Data, 977_3 Viscosity, 977-3 Isothermal Data, 977-3 Dynamic Data, 977-3 Cure Rates, 6K AS4 Fiber Property Validation Data, 12K AS4 Fiber Property Validation Data, AS4 Fiber Specific Heat Validation Data, AS4 Fiber Thermal Conductivity Validation Data, and AS4 Lamina Transverse Modulus Data.

While it may be hard to capture all the data associated with defining a new material, the AIM-C system is designed to help capture data along the insertion path. This can be done a number of different ways. Data can stored in the readiness level worksheets for each level (0 to 5) before the material is used for production. Many of the AIM-C

screens gather information, which helps define the problem and the associated constraints and criteria.

At this time, the general user cannot upload files into the AIM-C system. In the future, this may be possible, but for virus protection purposes, now it is not. An administrator can only alter the database structure. However, the information inside the database is completely created by the user for each project.

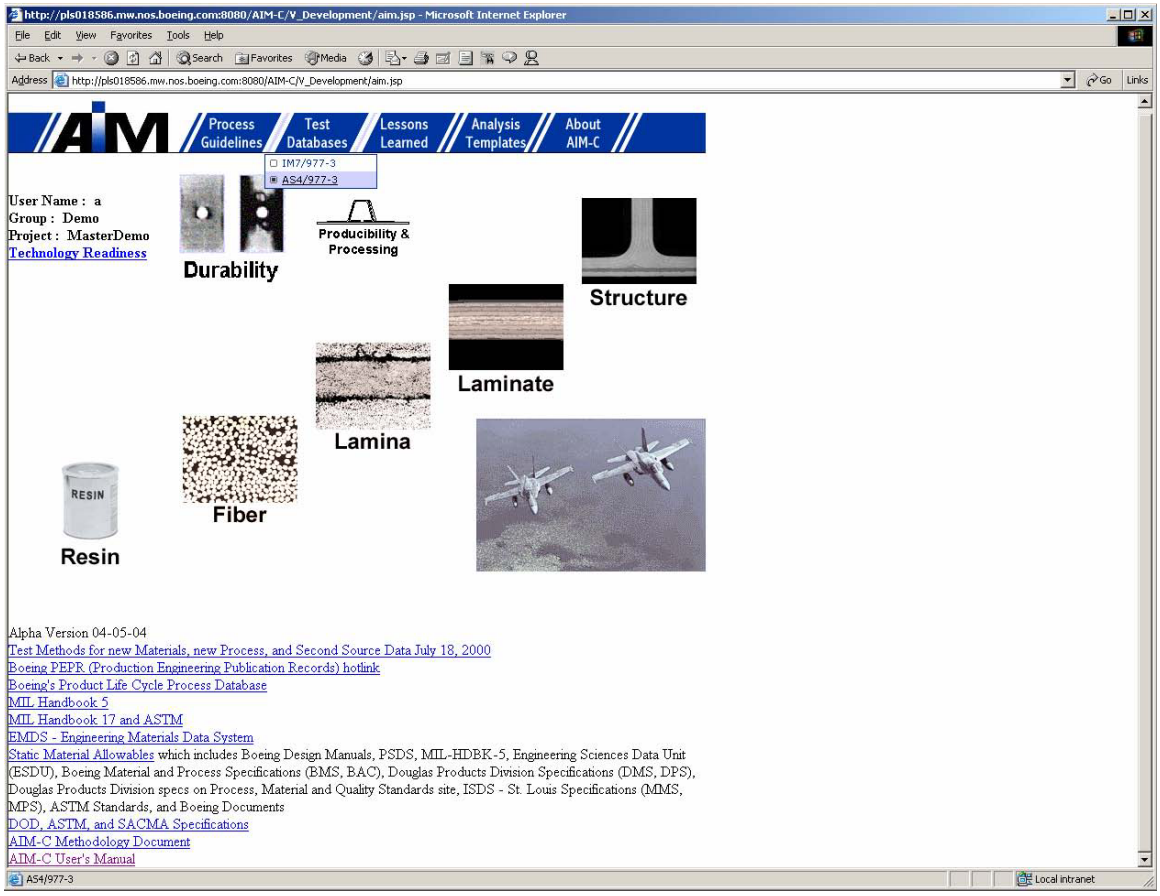


Figure E - 31. Test Database Information

Appendix 1:

A.1.0 Bug Tracker

A Bug Tracker has been installed for Boeing users to comment on bugs or features they would like to see fixed or added. This will link the user to a site at Canoga Park, CA. A series of text boxes and pull-down menus will allow the user to input the following information.

1. Category: RDCS, computational templates, database design, database implementation, distributed processing, other, or user interface
2. Reproducibility: always, sometimes, random, have not tried, unable to duplicate, N/A
3. Severity: feature, trivial, text, tweak, minor, major, crash, block
4. Product Version: V_0.0.2, V_0.0.1, V_0.1.0, …
5. Summary:
6. Description:
7. Additional Information:
8. View Status: public or private
9. Platform:
10. Operating System:
11. Step to Reproduce: