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INTERACTIVE MULTIMEDIA PRESENTATION FOR APPLIED COMPUTED TOMOGRAPHY: IMPACT

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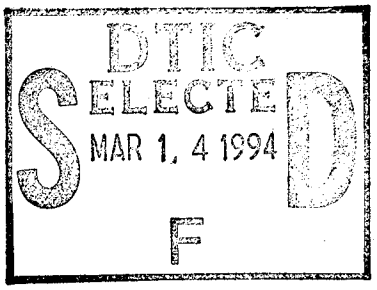

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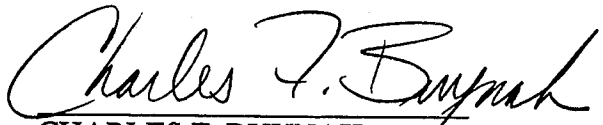

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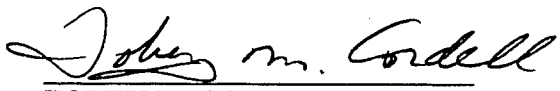

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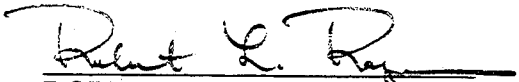

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An interactive multimedia presentation has been developed for viewing on a Macintosh workstation that summarizes the results of the "Advanced Development of X-ray Computed Tomography Applications" demonstration (CTAD) program. The Interactive Multimedia Presentation for Applied Computed Tomography (IMPACT) package includes the following areas: 1) Conclusions and Recommendations, 2) X-Ray Computed Tomography, 3) CT Application Stories, 4) Interactive Imaging Program and 5) For More Information.

The "Advanced Development of X-ray Computed Tomography Applications" demonstration (CTAD) program, sponsored by Wright Laboratory, generated significant amounts of data and conclusions on the application of X-ray computed tomography (CT) to aircraft structures, materials and components. Over 18 formal technical reports have been written for WL publication. The approach for summarizing the data has been to create a presentation package for use on a Macintosh computer containing the major conclusions of the CTAD program with a number of specific examples. The package can be used by an individual to review information or can be used by a presenter to an audience with an LCD screen and overhead projector. The interactive multimedia allows the users to move through the material at their pace, entering deeper levels of detail as desired. The presentation contains the summary conclusions of the CTAD program, background material on basic X-Ray CT, examples of the applications of computed tomography that were demonstrated in the CTAD program, an image processing program for demonstrating CT image analysis, and references for more information. The CD presentation package is available from Wright Laboratory.

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DISCLAIMER

The information contained in this document is neither an endorsement nor criticism for any X-ray imaging instrumentation or equipment used in this study.

SUMMARY

An interactive multimedia presentation has been developed for viewing on a Macintosh workstation that summarizes the results of the "Advanced Development of X-ray Computed Tomography Applications" demonstration (CTAD) program. The Interactive Multimedia Presentation for Applied Computed Tomography (IMPACT) package includes the following areas: 1) Conclusions and Recommendations, 2) X-Ray Computed Tomography, 3) CT Application Stories, 4) Interactive Imaging Program and 5) For More Information.

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1.0 INTRODUCTION and OVERVIEW

The goal of the Advanced Development of X-Ray Computed Tomography Applications Demonstration program (CTAD) was to identify applications for which computed tomography (CT) could be used cost-effectively in the evaluation of aircraft/aerospace structures, materials and components. The program was task assigned, with each task assignment allowing specific applications or application areas to be investigated individually. A number of technical reports were generated during the course of the program and were distributed to government and industry [1-21]. In order to summarize the significant results of the program in a suitable method for both technical presentation and individual review, the findings of the program were assembled in an interactive multimedia program and made available as a compact disk (CD) for use on Macintosh workstations. This project was titled, Interactive Multimedia Presentation for Applied Computed Tomography, (IMPACT).

The IMPACT program was written in Macromind Director, version 2.0. This software is advantageous for creating a product that can be used by a presenter to selectively instruct and audience from a vast resource of information. The program was also written in a manner that would allow an individual to examine the material by themselves and refer to various levels of technical detail for information. Because the final product is a compromise between a presentation and computer based learning tool, this report has been generated to provide some assistance to the user of IMPACT for accessing material of interest.

Note: This report uses italics in the text to denote action by the user of IMPACT.

1.1 IMPACT CD

The IMPACT CD is available from Wright Laboratory. The CD is written for Macintosh CD players. It contains over 70 MBytes of information. Figure 1.1-1 lists the major files and folders that make up IMPACT.

1.2 Startup modes

When the IMPACT CD is opened the window should show the file folder IMPACT 1.0 f. Opening this folder in the "view icon" window mode should show two blue WL icons, see Figure 1.2-1. One is titled "IMPACT Launcher" and the other "IMPACT short launcher." *Double click on* "IMPACT Launcher" *to start IMPACT and see the Wright Laboratory introduction to IMPACT.* This introduction takes approximately 1.5 minutes to run. The operation of this introduction may be highly dependent on the CD player and Macintosh hardware system you are using. This introduction involves sound and videos which may not be properly synchronized on slower computer systems or CD's. You may wish to copy the IMACT 1.0 f folder to your computer if you have 72 MBytes of space available and then run the application. If the introduction does not work properly on your system you may wish to bypass it. Be patient your first time through the introduction in order to see how your computer responds to the sound and video effects.

IMPACT 1.0 *f*

Name	Size	Kind	Label	Last Modified
CTAD CT Apps Composites	7,718K	MacroMind Directo...	Cool	Mon, May 9, 1994, 11:06 PM
CTAD Conclusions	6,206K	MacroMind Directo...	Hot	Sun, May 8, 1994, 8:42 PM
Russo Movie.Apple Video	5,733K	Simple Player docu...	Project 1	Mon, Feb 14, 1994, 12:05 AM
CTAD CT Apps Castings	5,240K	MacroMind Directo...	Cool	Sun, May 8, 1994, 10:52 PM
CTAD CT Apps AdvMat	4,610K	MacroMind Directo...	Cool	Mon, May 9, 1994, 11:01 PM
CTAD Computed Tomogr...	4,179K	MacroMind Directo...	Hot	Sun, May 8, 1994, 10:23 PM
CTAD CT Apps ComplexS...	3,329K	MacroMind Directo...	Cool	Sun, May 8, 1994, 10:44 PM
Bossi Movie.Apple Video	3,077K	Simple Player docu...	Project 1	Sun, Feb 13, 1994, 11:12 PM
CTAD CT Apps Electronics	2,793K	MacroMind Directo...	Cool	Sun, May 8, 1994, 10:38 PM
IMPACT Launcher	2,111K	application program	—	Thu, May 19, 1994, 1:27 PM
IMPACT Short Launcher	1,775K	application program	—	Thu, May 19, 1994, 1:31 PM
CTAD CT FYI	1,764K	MacroMind Directo...	Hot	Mon, May 16, 1994, 9:52 AM
CTAD Menu	882K	MacroMind Directo...	Hot	Tue, May 10, 1994, 1:16 PM
Delamination QT	767K	Simple Player docu...	Project 1	Sun, May 8, 1994, 8:52 PM
CT Slice Series QT	704K	Simple Player docu...	Project 1	Sun, May 8, 1994, 8:43 PM
Transverse QT	662K	Simple Player docu...	Project 1	Sun, May 8, 1994, 8:43 PM
Film.Anim.QT	609K	document	In Progress	Sun, Feb 20, 1994, 12:23 PM
(TT Tr Rot.Model) Anima...	494K	document	In Progress	Wed, Feb 23, 1994, 2:16 AM
TT w/rays.shdw.QT.Gra...	483K	document	In Progress	Mon, Feb 7, 1994, 3:07 PM
(CT Transition.Model) A...	315K	document	In Progress	Wed, Feb 23, 1994, 12:36 AM
Image 1.44	284K	application program	Personal	Tue, Jul 6, 1993, 11:34 AM
CTAD CT Imaging	147K	MacroMind Directo...	Hot	Sun, May 8, 1994, 11:19 PM
Antenna.tif	126K	document	Personal	Thu, Apr 22, 1993, 9:29 AM
Cursor Resources	11K	document	—	Fri, Nov 19, 1993, 3:49 PM
References	11K	TeachText document	Project 2	Thu, Jun 10, 1993, 11:57 AM
Reports	11K	TeachText document	Project 2	Tue, Jun 15, 1993, 11:49 AM
Demo Folder	—	folder	Project 2	Thu, May 19, 1994, 1:25 PM
Put in System Folder	—	folder	—	Thu, Feb 24, 1994, 10:52 AM
Read Me! *f*	—	folder	—	Mon, May 16, 1994, 9:37 AM
Support Files	—	folder	—	Thu, May 19, 1994, 1:31 PM
TIFF files	—	folder	—	Sun, Feb 27, 1994, 9:49 PM

Figure 1.1-1 Major Files and Folders in IMPACT 1.0 *f*

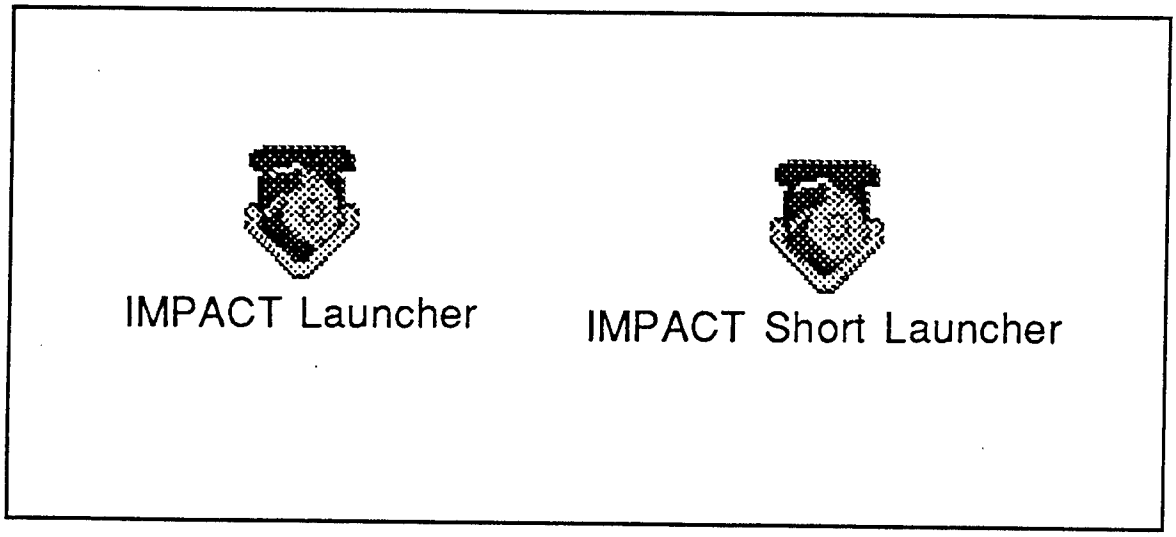

Figure 1.2-1 IMPACT Launcher Icons

When IMPACT first begins it presents a mouse icon. *Hold the shift key and click on the mouse to open the configuration menu. Set the sound level, check memory and color depth. Click on the mouse to begin IMPACT.* IMPACT will proceed with the WL Logo and slides of aircraft. The presentation will stop to explain that when the curse symbol appears as a flashing mouse symbol, you must click the mouse to continue. This will allow you to read the screens at your own speed. At the end of the WL introduction, IMPACT will pause to allow you to select a "Help" and/or and "About" window. You may proceed to the MAIN MENU of IMPACT by clicking on the proceed button.

The introduction may be bypassed if desired, particularly if you are using IMPACT a second time or more. *Double click on* "IMPACT short launcher" *to start the application and go directly to the Main Menu* . IMPACT will begin with the option to set the sound level, check memory and color depth by holding the shift key and clicking the mouse. Clicking on the mouse with the shift key up will start the IMPACT application. The WL logo and slides of aircraft will appear with music. When this sequence is complete, the MAIN MENU will appear.

1.3 IMPACT Main Menu

The MAIN MENU of IMPACT is shown in Figure 1.3-1. The five section titles are "Conclusions & Recommendations," "X-Ray Computed Tomography," "CT Application Studies," "Interactive Imaging Program," and "For More Information...". Each of these selections is discussed in Sections 2 through 6 of this report. *Click on the box containing the title to begin the section of your choice.* Selection of the "Exit" box will conclude the IMPACT application. This is the only way to exit IMPACT. In all further operations, one must return to the MAIN MENU in order to properly exit the program.

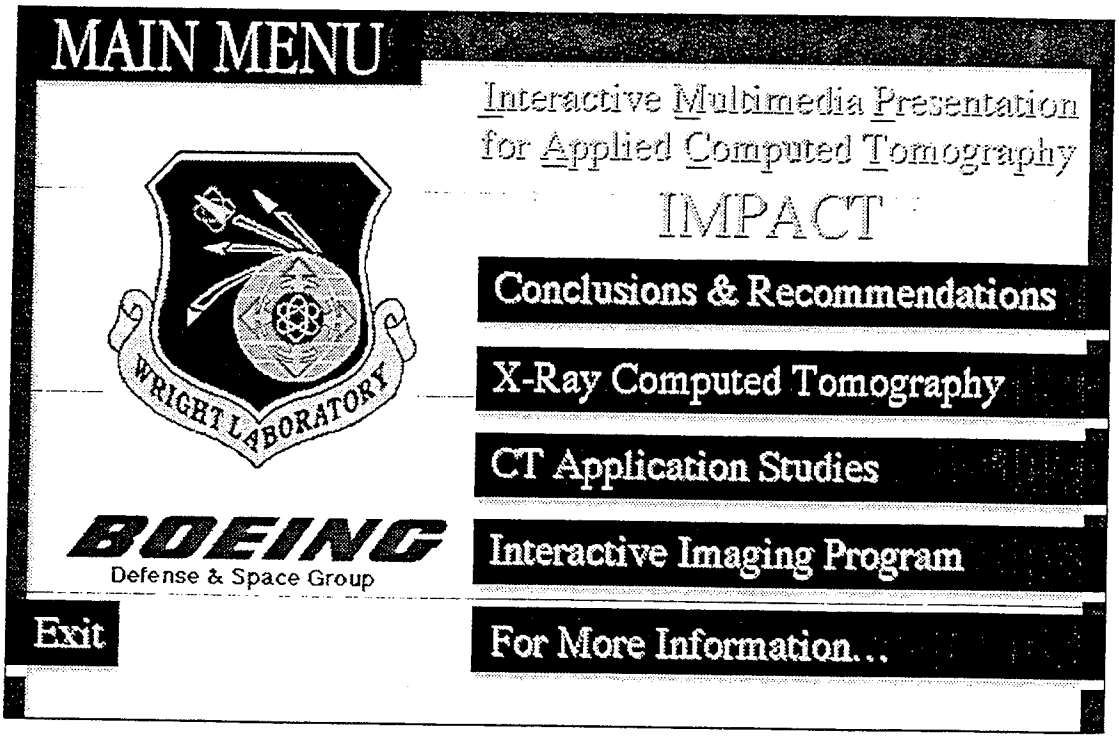

Figure 1.3-1 IMPACT Main Menu

2.0 CONCLUSIONS and RECOMMENDATIONS

2.1 Overview

The "Conclusions and Recommendations" section begins by loading a new menu. In the upper right of the screen is an icon which when selected shows a map of the possible screens available in this section. *Click on the "globe" icon to see the map and click on the map to return the display.* This icon exists throughout the section to be used for guidance as to where you are. By using the forward and backward arrows one can move through the various detail locations in section. The MENU button at the upper right returns to the MAIN MENU. The arrow buttons move through the "Conclusions & Recommendation" section.

The "Conclusions and Recommendations" menu contains four titled buttons: "General Conclusions," "Economic Payback," "Cost Effective Applications," and "Recommendations." Each of these areas can be reached directly by placing the mouse cursor in the box and clicking the mouse. These sections will also be reached in sequence by using the upper right forward button.

Clicking on the film strip icon in the upper left photograph of Dr. Richard Bossi will initiate a video clip. Clicking on the image of the SRAM rocket motor in the lower center of the screen will enlarge the image to full screen. Clicking again on the image will return to the menu. (This protocol will work on images and photographs throughout the IMPACT program.) Clicking on the line trace data in the lower left which is taken from the SRAM

rocket motor image will enlarge the data trace to full screen. Clicking again on the image will return to the menu.

2.2 General Conclusions

The General Conclusion screen (labelled 1 of 5 in the upper left) shows the major points about CT in progression ending with three boxes: "CT is a Cost Effective Engineering Tool," CT Advantages," and "CT Limitations." *Click on any box to enlarge it to full screen for easier reading.*

2.3 Economic Payback

The Economic Payback screen are labelled 2 of 5 and 3 of 5 in the upper left. *Click on the "Report" box which appears in the upper left for each screen to read more detailed text. Use the sliding bar on the right side of the text box to move through the text. Use the Return button to exit from the text, returning to the Economic Benefit screens.*

The first Economic Benefit screen contains four boxes at the bottom. *Click on each box to see further details. Use the* Return *button to regain the* Economic Benefit *screen . Use the* REPORT *button for text detail. Click on figures adjacent to the text box in order to see them full screen.*

The second Economic Benefit screen lists seven product lifecycle activities on the left side of the screen. *Click on any of the activities to see further examples.* The examples will appear as gray boxes on the right of the screen. Each box containing a red dot has an example story to go with it. *Click on the gray box and an example story will be shown. Click on the images to make them full screen. Clicking on the full screen image will reduce them to the small size. Click on the* REPORT *button at the top of the screen for text information. Use the* RETURN *button to return to the* Economic Benefit *screen.*

2.4 Cost Effective Applications

The Cost Effective Applications screen (labelled 4 of 5 in the upper left) shows a matrix of Product Development Processes and CT Application Areas. There are no interactive features on this screen. This screen however will be duplicated in the CT Application Study Section which is described in section 4 of this report.

2.5 Recommendations

The Recommendations screen (labelled 5 of 5 in the upper left) summarizes Boeing's recommendations based on the CTAD investigations. *Click on the REPORT button to read details on the recommendations. Click on the MENU button to return to the* Conclusions & Recommendations *menu. Click on* MENU *button again to return to the* MAIN MENU.

3.0 X-RAY COMPUTED TOMOGRAPHY

3.1 Overview

The X-Ray Computed Tomography section begins by loading the "Introduction to CT" menu. The "Introduction to CT" menu contains four titled buttons: "Introduction to CT," "CT Basics," "Systems," and "Standards/Phantoms." Each of these areas can be reached directly by placing the mouse cursor in the box and clicking the mouse. These sections will also be reached in sequence by using the upper forward arrow button in the upper right of the screen. The MENU button at the upper right returns to the MAIN MENU.

3.2 Introduction to CT

Clicking on the "Introduction to CT" button shows a new menu with the selections of "Overview," "Radiography vs. CT," "Industrial CT," and "Direction of CT Imaging." The MENU button at the upper right returns to the first "Introduction to CT" menu. The arrow buttons in the upper right proceed through the four selections on the menu screen in sequence.

The "Overview" button presents a screen that outlines advantages and limitations of CT.

The "Radiography vs. CT" button brings up a "CT Comparison vs. Film" screen. *Click on the* REPORT *button in the upper right to see a comparison of a photograph, radiograph and CT image of an ignitor.* The "CT Comparison vs. Film" screen contains a number of interactive sequences. By using the mouse to click on locations in the screen various sequences of how radiography and CT are performed. Both 2nd and 3rd generation CT motions are demonstrated. *Click on the backward and forward arrow buttons in sequence, so that this screen may be restarted to review the radiographic process. Click on the forward arrow button or the* MENU *button to move to another screen.*

The "Industrial CT Systems" button presents a screen with four photograph examples of CT systems. *Click on each photograph to see them full screen. Click on the REPORT buttons in the upper right to see graphs.*

The "Direction of CT Imaging" button shows a screen that explains the speed and cost of CT system in roughly the capability and dollar values of 1993. *Click on the* MENU *button to back up the sequence. Click again on the* MENU *button to obtain the original* "Introduction to CT" *screen.*

3.3 CT Basics

The "CT Basics" screen presents a series of information on CT imaging. *Click on the mouse to begin.* The areas presented include "Attenuation," "Backprojection," "Resolution," "Contrast Sensitivity," and "Artifacts." They are listed at the bottom of the screen. *Click on the item of interest at the bottom of the screen or use the arrow keys at the upper right to proceed.* Each subsequent screen may contain optional details to click and observe, including the REPORT key that may appear in the upper right. *Click on the* MENU *button in the upper right to return to the original* "Introduction to CT" *screen.*

3.4 Systems

The "Systems" screen presents information on CT systems in four categories: X-Ray techniques used in the CTAD program, CT system generations, Generic CT system and CT system attributes. *Click on any of the four titles to view detail information.*

The "X-ray Techniques" selection presents a screen listing seven techniques. *Click on the technique of interest.* A more detailed information screen will appear. *Click on the REPORT key for additional information. Use the* RETURN *keys to get back to the* "X-Ray Techniques" *menu.*

The "CT system generations" selection presents a screen listing four titles. *Click on title of interest to see additional information. Use the* RETURN *keys to get back to the* "Generations " *menu.*

The "Generic CT system" selection presents a schematic of a generic CT system.

The "CT system attributes" selection presents a screen showing three boxes. *Click on the System Attribute of interest in the left box.* The right boxes will show the ramifications and a text discussion of the attribute. *Use the slide bar on the right of the text box to review the entire text. Click on the* MENU *button to back up the sequence. Click again on the* MENU *button to obtain the original* "Introduction to CT" *screen.*

The Cost Effective Applications screen shows a matrix of Product Development Processes and CT Application Areas. There are no interactive features on this screen. This screen however will be duplicated in the CT Application Study Section which is described in section 4 of this report.

3.5 Standards/Phantoms

The "Standards/Phantoms" selection begins a sequence which discusses the use of standards and phantoms in CT imaging. *Click the mouse button after reviewing the introduction screen to see screen containing three boxes. Click on the phantom type of interest in the left box.* Picture icons appear in the upper right box. *Click on the icons to reveal additional information and text report.* Figures called out in the report text can be accessed from the Figure bar at the bottom of the text box. *Click on images to enlarge them. Use the* RETURN *button to back up to the* Standards/Phantoms screens. *Click on* MENU *button again to return to the* "Introduction to CT" *menu. Click again on the* MENU *button to return to the* MAIN MENU.

4.0 CT APPLICATION STUDIES

4.1 Overview

A major effort of the CTAD program was the investigation of a number of technical areas to acquire stories demonstrating the economic application of CT to a range of problems. The overall conclusion was that CT could be economically applied in the life cycle of aerospace products for the generalized categories listed in Figure 4.1-1. The IMPACT program used the symbol identifier to correlate the economic benefit generalized category with the cross-correlation table of Figure 4.1-2. This figure is used in IMPACT to allow the reader to

Electronics, Complex Systems, Castings, Composites and Advanced Materials and Processes, and to select within those applications areas the location in a product life cycle where the economic benefit may be found. *The IMPACT user clicks with the mouse in the Application Areas heading box (marked with the topic area red dot) to begin a search through the stories.*

At this point selecting the forward button does nothing. The backward button returns to the list of generalized economic benefit categories. The MENU button returns to the MAIN MENU. Note: throughout the CT Application Studies section, the MENU button in the upper right will exit the section, returning the MAIN MENU screen.

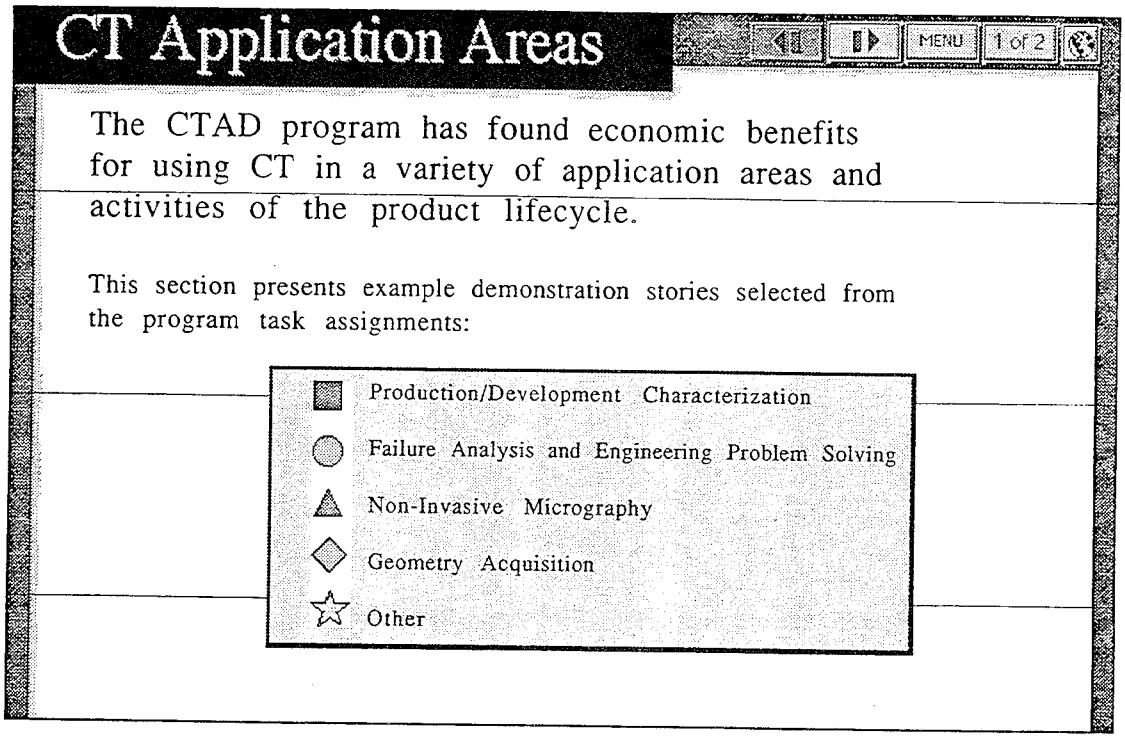

Figure 4.1-1 Economic Benefit Generalized Categories Screen

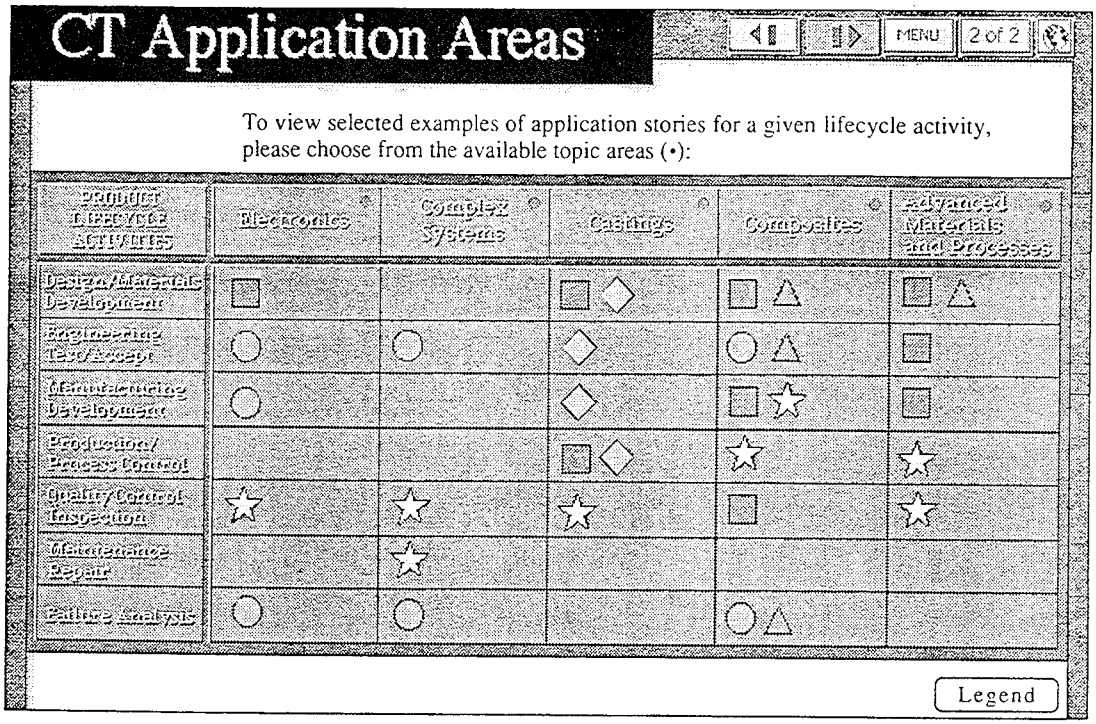

Figure 4.1-2 CT Application Areas Cross-Correlation Table

4.2 Electronics

Selecting the Electronics section brings up the menu shown in Figure 4.2-1. This menu is the first of the five application area menus. The menu shows that application stories dealing with electronics can be found for five of the the seven product life cycle activities used in IMPACT.

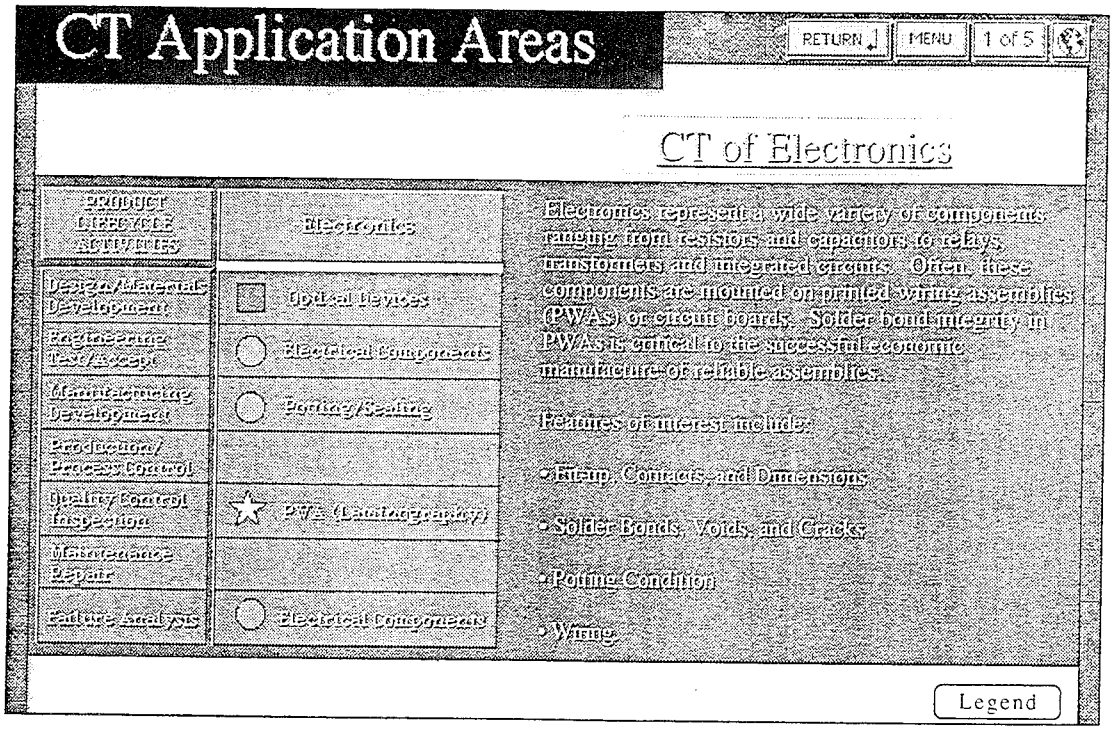

Figure 4.2-1 CT of Electronics Story Selection Menu

The example electronics and electrical component stories for each of the product lifecycle activities are identified by the economic benefit category symbol and by an identifier of the type of stories that may be found in each available story selection box. *Click on the boxes containing the economic benefit category symbol to explore the stories.* Figure 4.2-2 tabulates details on the stories that may be found in the Electronics Story Section. *Click on the gray story boxes to see the specific stories. Click on the images to see them enlarged and in many cases to see callouts to highlights in the images. Clicking on the enlarged, full screen images, returns to the small multi-image display. Click on the* "Report" *box in the upper right to obtain a pop-up box with detailed text information about the application story. Use the slide bar on the right to advance or retrace the text.* In some cases more than one page of information is available on an application story. *In the case of multiple pages use arrow buttons to advance from first to second page and back. When viewing the* "Report" *text, selecting the figure numbers at the bottom of the report pop-up box will show the figure to the left in small scale. For example to select from figure 6-10 or figures 1-5 click on the* "Figures" *box at lower left of the* Report *text pop-up box.* In the upper right of the screen is a globe icon. *Click on the "globe" icon to see a map of the Electronics area. Click on the map to return the display.*

Product Lifecycle Activities	Example Story	Identifier	# of Pages	Notes/Comments
Design/Material Development	Optical Rotary Transducer	Optical Devices	1	CT imaging to internal configuration
Engineering Test/Accept	RF Cable/ Connector	Electrical Components	1	CT as an alternative to destructive sectioning
	Military Antenna	Electrical Components	1	CT for internal measurements
Manufacturing Development	Potted Cable Assembly	Potting	1	Internal configuration evaluation
	Fiber Optic Connector	Potting	2	Evaluation of position and potting of fiber optic connector
Quality Control Inspection	Printed Wiring Assembly	PWA Laminography	1	Laminographic imaging for circuit board solder evaluation
Failure Analysis	Avionics Power Transducer	Electrical Components	1	Evaluation of misaligned core
	Relay	Electrical Components	1	CT detection of improper hold down straps

Figure 4.2-2 Tabulation of Electronics Example Stories

4.3 Complex Systems

Selecting the Complex Systems section brings up the menu shown in Figure 4.3-1. This menu is the second of the five application area menus. This menu may take a few seconds to load. The menu shows that application stories dealing with complex systems can be found for four of the seven product life cycle activities used in IMPACT.

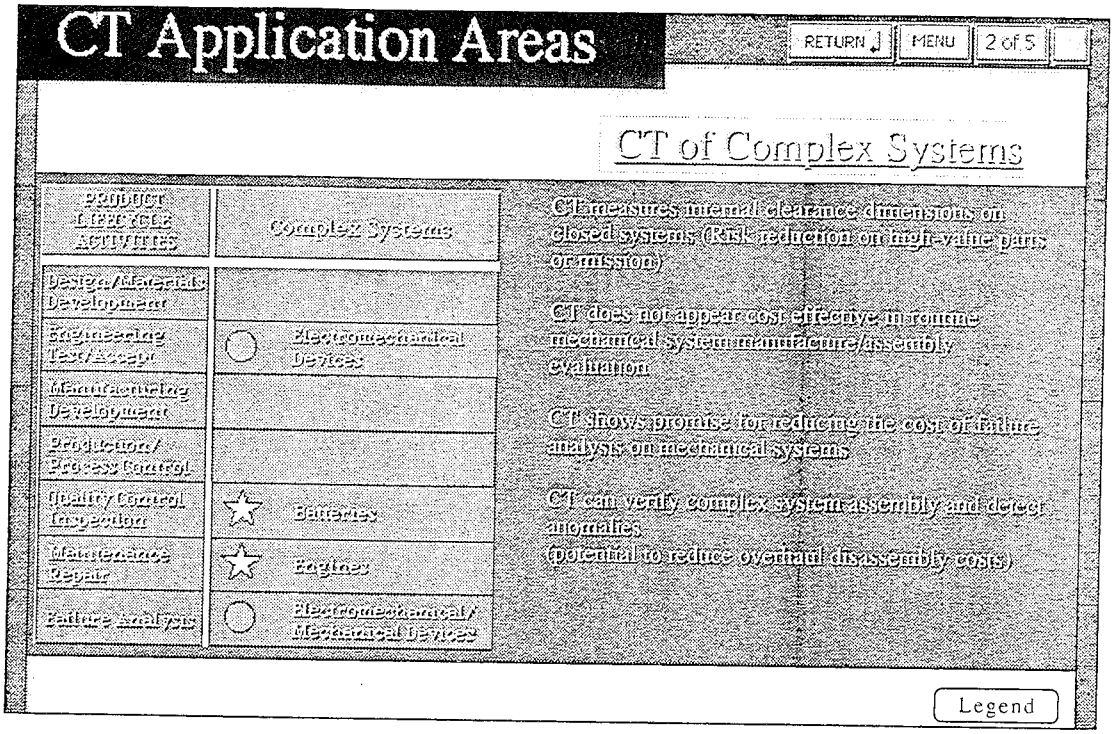

Figure 4.3-1 CT of Complex System Example Story Selection Menu

The complex system example stories for each of the product lifecycle activities are identified by the economic benefit category symbol and by an identifier of the type of stories that may be found in each available story selection box. *Click on the boxes containing the economic benefit category symbol to explore the stories.* Figure 4.3-2 tabulates details on the stories that may be found in the Complex System Story Section. *Click on the gray story boxes to see the specific stories. Click on the images to see them enlarged and in many cases to see callouts to highlights in the images. Clicking on the enlarged, full screen images, returns to the small multi-image display. Click on the* "Report" *box in the upper right to obtain a pop-up box with detailed text information about the application story. Use the slide bar on the right to advance or retrace the text.* In some cases more than one page of information is available on an application story. *In the case of multiple pages use arrow buttons to advance from first to second page and back. When viewing the* "Report" *text, selecting the figure numbers at the bottom of the report pop-up box will show the figure to the left in small scale. For example to select from figure 6-10 or figures 1-5 click on the* "Figures" *box at lower left of the* Report *text pop-up box.*

Product Lifecycle Activities	Example Story	Identifier	# of Pages	Notes/Comments
Engineering Test/Accept	Safe & Arm Device	Electro-mechanical Devices	2	Detection of debris and measurement of clearance
	Hydraulic Slat Actuator	Electro-mechanical Devices	1	Internal configuration
Quality Control Inspection	Missile Battery	Batteries	2	CT imaging for internal conditions
Maintenance Repair	Cruise Missile Engine	Engines	3	Configuration control and anomaly detection. Comparison of X-ray energies for large objects
Failure Analysis	Autobrake	Electro-mechanical Devices	2	Detection of misplaced or stuck internal components
	DC Torque Motor	Electro-mechanical Devices	1	Evaluation of failure mode without disassembly
	Aircraft Fuel Line	Mechanical Devices	1	CT examination under environmental conditions

Figure 4.3-2 Tabulation of Complex System Example Stories

4.4 Castings

Selecting the Castings section brings up the menu shown in Figure 4.4-1. This menu is the third of the five application area menus. This menu may take a few seconds to load. The menu shows that application stories dealing with castings can be found for five of the seven product life cycle activities used in IMPACT. In most cases more than one story can be found.

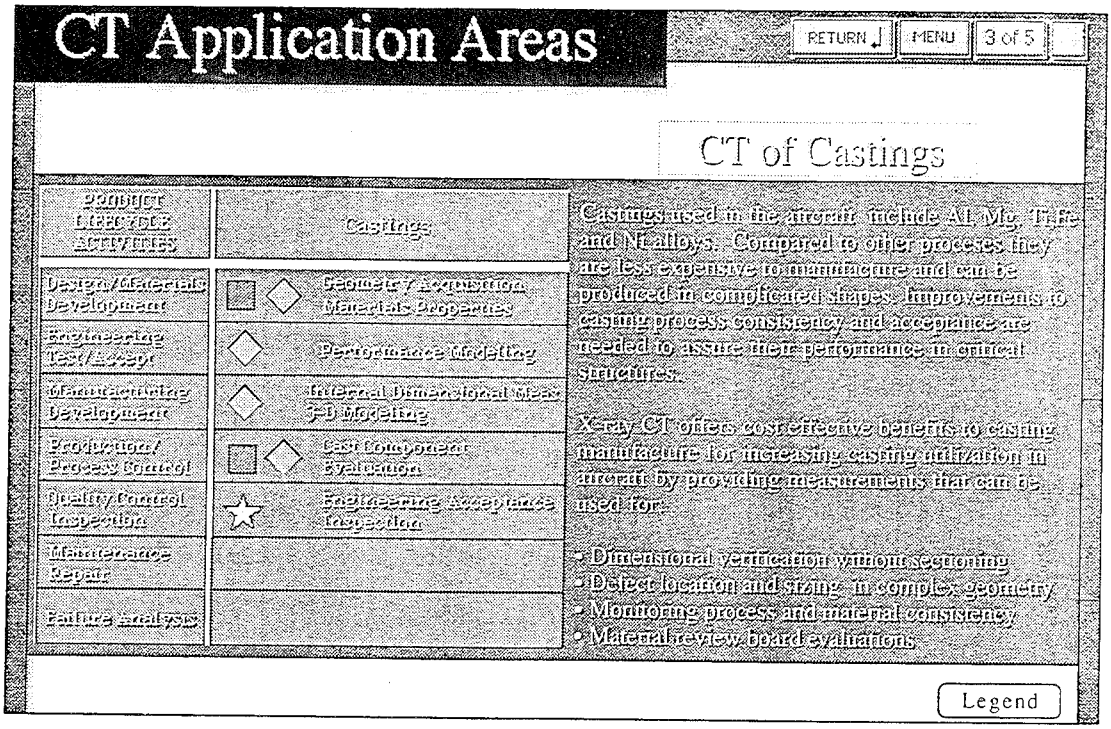

Figure 4.4-1 CT of Casting Example Story Selection Menu

The example stories for each of the product lifecycle activities are identified by the economic benefit category symbol and by an identifier of the type of stories that may be found in each available story selection box. *Click on the boxes containing the economic benefit category symbol to explore the stories.* Figure 4.4-2 tabulates details on the stories that may be found in the Advanced Materials and Processes Story Section. *Click on the gray story boxes to see the specific stories. Click on the images to see them enlarged and in many cases to see callouts to highlights in the images. Clicking on the enlarged, full screen images, returns to the small multi-image display. Click on the* "Report" *box in the upper right to obtain a pop-up box with detailed text information about the application story. Use the slide bar on the right to advance or retrace the text.* In some cases more than one page of information is available on an application story. *In the case of multiple pages use arrow buttons to advance from first to second page and back. When viewing the* "Report" *text, selecting the figure numbers at the bottom of the report pop-up box will show the figure to the left in small scale. For example to select from figure 6-10 or figures 1-5 click on the* "Figures" *box at lower left of the* Report *text pop-up box.*

Product Lifecycle Activities	Example Story	Identifier	# of Pages	Notes/Comments
Design/Material Development	Flight Control Wheel	Geometry Acquisition	1	CT imaging to obtain 3D CAD model
	B-17 Tail Wheel	Geometry Acquisition	2	Recreate drawing using CT on an existing part generating solid model and stereolithography model
	Cast Al Tensile Specimens	Materials Properties	2	Comparison of CT data with tensile test specimen failure data
Engineering Test/Accept	Drum Casting	Performance Modeling	2	Generation of data for finite element modeling from CT measurements
Manufacturing Development	Discharge Fitting	Internal Dimensional Measurement	2	CT imaging for measurement of internal spacing
	Cast Al Coupon	3D Model	2	Creation of a 3D model and a stereolithography representation of the object with internal defect
Production & Process Control	Flap Control Unit Housing	Cast Component Evaluation	1	CT detection and location of defect not detectable by radiography
	Hydraulic Reservoir Casting	Cast Component Evaluation	1	CT of complex geometry object. Quantitative evaluation of the effects of hot isostatic processing
Quality Control Inspection	Hydraulic Reservoir Casting	Engineering Acceptance	1	Evaluation of the extent of a defect for product salvage
	Selectively Reinforced Casting	Inspection	1	Position of imbedded structure
	Turbine Blades	Inspection	1	Dimensional measurements

Figure 4.4-2 Tabulation of Casting Example Stories

4.5 Composites

Selecting the Composites section brings up the menu shown in Figure 4.5-1. This menu is the fourth of the five application area menus. This menu may take a few seconds to load. The menu shows that application stories dealing with composites can be found for six of the seven product lifecycle activities used in IMPACT. In most cases more than one story can be found.

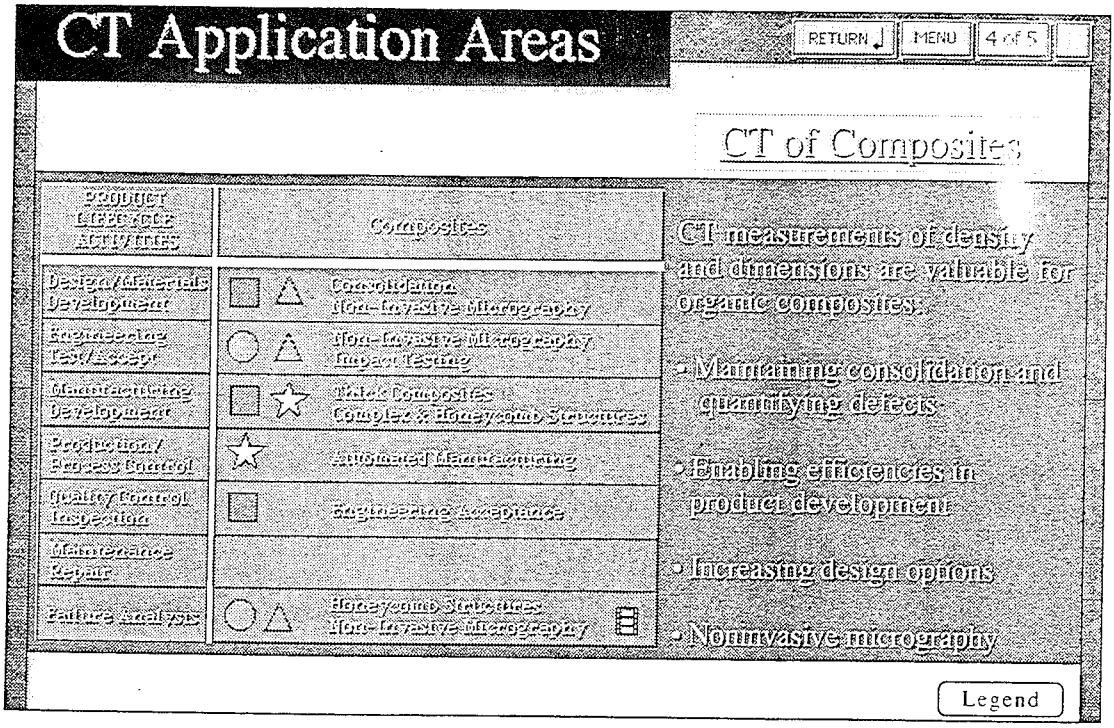

Figure 4.5-1 CT of Composites Example Story Selection

The composites example stories for each of the product lifecycle activities are identified by the economic benefit category symbol and by an identifier of the type of stories that may be found in each available story selection box. *Click on the boxes containing the economic benefit category symbol to explore the stories.* Figure 4.5-2 tabulates details on the stories that may be found in the Composites Application Story Section. *Click on the gray story boxes to see the specific stories. Click on the images to see them enlarged and in many cases to see callouts to highlights in the images. Clicking on the enlarged, full screen images, returns to the small multi-image display. Click on the* "Report" *box in the upper right to obtain a pop-up box with detailed text information about the application story. Use the slide bar on the right to advance or retrace the text.* In some cases more than one page of information is available on an application story. *In the case of multiple pages use arrow buttons to advance from first to second page and back. When viewing the* "Report" *text, selecting the figure numbers at the bottom of the report pop-up box will show the figure to the left in small scale. For example to select from figure 6-10 or figures 1-5 click on the* "Figures" *box at lower left of the* Report *text pop-up box.*

Product Lifecycle Activities	Example Story	Identifier	# of Pages	Notes/Comments
Design/Material Development	Pultruded Rod	Consolidation	1	Correlation of consolidation with shear strength
	2-D Composite	Non-Invasive Micrography	1	Comparison of photomicrograph with CT
Engineering Test/Accept	Fastener Test Coupon	Non-Invasive Micrography	1	Cracks and delaminations imaged with CT. 3D model from mathematical morphology image processing.
	G/E Impacted Panel	Impact Testing	2	Delamination planes in impact damaged panel revealed by mathematical morphology image processing.
Manufacturing Development	Rotor Grip	Thick Composites	1	CT imaging of porosity and wrinkling
	Thick Composite Beam	Thick Composites	1	Detection of fiber waviness
	Sine Wave Spar	Complex Structures	2	Imaging of delaminations and sequence along spar
	Trailing Edge	Honeycomb Structures	1	Large honeycomb structure with internal septa
Production & Process Control	Pultruded Airfoil	Automated Manufacturing	1	Voids and delaminations
Quality Control Inspection	Tube Wall Thickness	Engineering Acceptance		No images available
Failure Analysis	767 Spoiler	Honeycomb Structure	1	Water measurement in honeycomb
	Graphite-Epoxy Honeycomb Panel	Failure Analysis	1	CT imaging greatly aids in the determination of failure mode
	Fastener Hole	Failure Analysis	1	No photograph of the test sample is available. *In the enlarged mode of the* "180 CT Slice Series", "3D Model of Cracks and Delaminations" *and* "3D Model of Cracks" *click on the film strip icon to see a video showing a series of CT slices in the case of the* "180 CT Slice Series" *or a video of the 3D models in rotation. Click on the* "RETURN" *button at the top of the field to return to the enlarged mode image.*

Figure 4.5-2 Tabulation of Composites Example Stories

4.6 Advanced Materials and Processes

4.6 Advanced Materials and Processes

Selecting the Advanced Materials and Processes section brings up the menu shown in Figure 4.6-1. This menu is the fifth of the five application area menus. This menu may take a few seconds to load. The menu shows that application stories dealing with advanced materials can be found for five of the seven product life cycle activities used in IMPACT. In most cases more than one story can be found.

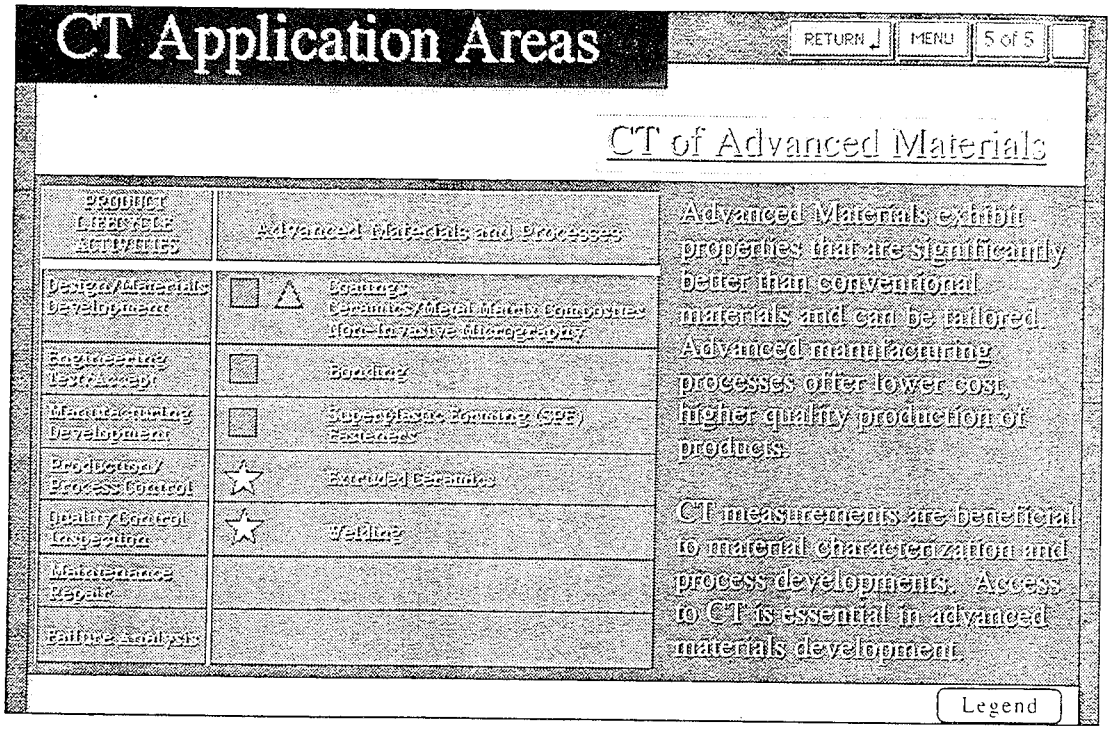

Figure 4.6-1 CT of Advanced Materials and Processes Example Story Selection

The example stories for each of the product lifecycle activities are identified by the economic benefit category symbol and by an identifier of the type of stories that may be found in each available story selection box. *Click on the boxes containing the economic benefit category symbol to explore the stories.* Figure 4.6-2 tabulates details on the stories that may be found in the Advanced Materials and Processes Story Section. *Click on the gray story boxes to see the specific stories. Click on the images to see them enlarged and in many cases to see callouts to highlights in the images. Clicking on the enlarged, full screen images, returns to the small multi-image display. Click on the* "Report" *box in the upper right to obtain a pop-up box with detailed text information about the application story. Use the slide bar on the right to advance or retrace the text.* In some cases more than one page of information is available on an application story. *In the case of multiple pages use arrow buttons to advance from first to second page and back. When viewing the* "Report" *text, selecting the figure numbers at the bottom of the report pop-up box will show the figure to the left in small scale. For example to select from figure 6-10 or figures 1-5 click on the* "Figures" *box at lower left of the* Report *text pop-up box.*

Product Lifecycle Activities	Example Story	Identifier	# of Pages	Notes/Comments
Design/Material Development	SiC Coating	Coatings	1	CT imaging of coating layer and core
	Fiberceramic	Ceramics	1	Ceramic with Ti honeycomb mesh
	Al Metal Matrix Composite	Metal Matrix Composite	1	Al metal matrix rod internal porosity
	3-D Braid	Non-Invasive Micrography	1	High resolution volumetric CT imaging
Engineering Test/Accept	Adhesive Bond Quality	Bonding	1	Bond evaluation to assist process development.
	Multilayer Bond	Bonding	1	Delaminations on multiple layer in complex structure. No part photograph available.
Manufacturing Development	SPF Airfoil Section	SPF	3	CT imaging of complex SPF shaped parts.
	Fasteners	Fasteners	2	Comparison of pre and post sectioning CT imaging. Measurement of fastener fit.
	Injection Molding		1	Porosity and injection flow in injection molded plastic structure
Production & Process Control	Extruded CMC Bits	Extruded Ceramics	1	Defect detection
Quality Control Inspection	E-Beam Weld	Welding	1	Porosity detection and location in weld

Figure 4.6-2 Tabulation of Advanced Materials and Processes Example Stories

5.0 INTERACTIVE IMAGING PROGRAM

5.1 Overview

The "Interactive Imaging Program" section presents information on the use of the National Institute of Health image processing program "IMAGE." This is a public domain program that is very useful. IMPACT contains both versions 1.44 and 1.52. This section was prepared for IMAGE 1.44. The section consists of five screens which describe several uses of IMAGE for the examination of CT images. Screen 5 of 5 contains a box for launching IMAGE 1.44; however, this function may not work depending on the configuration of the system being used with the CD. Instead, after reviewing the information in this section, exit the IMPACT program and launch IMAGE from the CD file window as described below.

Click on the MENU *box in the upper right to bring up the* MAIN MENU. *Click on the* Exit *box. To use* IMAGE 1.44, *double click on the* IMAGE 1.44 *file name or icon in the*

IMPACT 1.0 *f window. To use* IMAGE 1.52 *open the* Support Files Directory *in* IMPACT 1.0 *f. Now open the* NIH Directory *and double click on* IMAGE 1.52.

5.2 TIFF Files

The use of the IMAGE program requires the input of data files. The program may be used to analyze any suitable data files you may have. Included in IMPACT CD, under the TIFF Files Directory, are a number of images that may be opened by IMAGE for your review.

With the IMAGE *program open, select the* "File" *pull down menu at the top of the window. Select "Import" from the menu. Click on the* TIFF *format style. Highlight the data file of interest you wish to view by finding it in the appropriate disk or folder for the file lists. Select the* "Open" *button for IMAGE to view the data file.*

6.0 FOR MORE INFORMATION

6.1 Overview

The "For More Information..." section begins by loading the "For Your Information..." menu. This menu contains four titled buttons: "CT Systems Used," "Documentation," "Acknowledgements," and "Multimedia." Each of these areas can be reached directly by placing the mouse cursor in the box and clicking the mouse. These sections will also be reached in sequence by using the upper forward arrow button in the upper right of the screen. The MENU button at the upper right returns to the MAIN MENU.

6.2 CT Systems Used

This section lists a number of the CT systems used during the CTAD program with information about the systems. *Click in the boxes under the* ENERGY *heading to see the system types for each category. Click on the vendor name or facility name to see information on selected systems. Use the* RETURN *button to return to the* CT Systems *table.*

6.3 Documentation

This section lists the technical reports created in the CTAD program.

6.4 Acknowledgements

This section lists many of the great many people who contributed to the CTAD program. *Use the slide bar on the right of the* Acknowledgements *list to move through the lists of those involved to various degrees in the program. Click on the CT scanner image to see photographs.*

6.5 Multimedia

This section lists the individuals involved in the multimedia production of IMPACT.

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