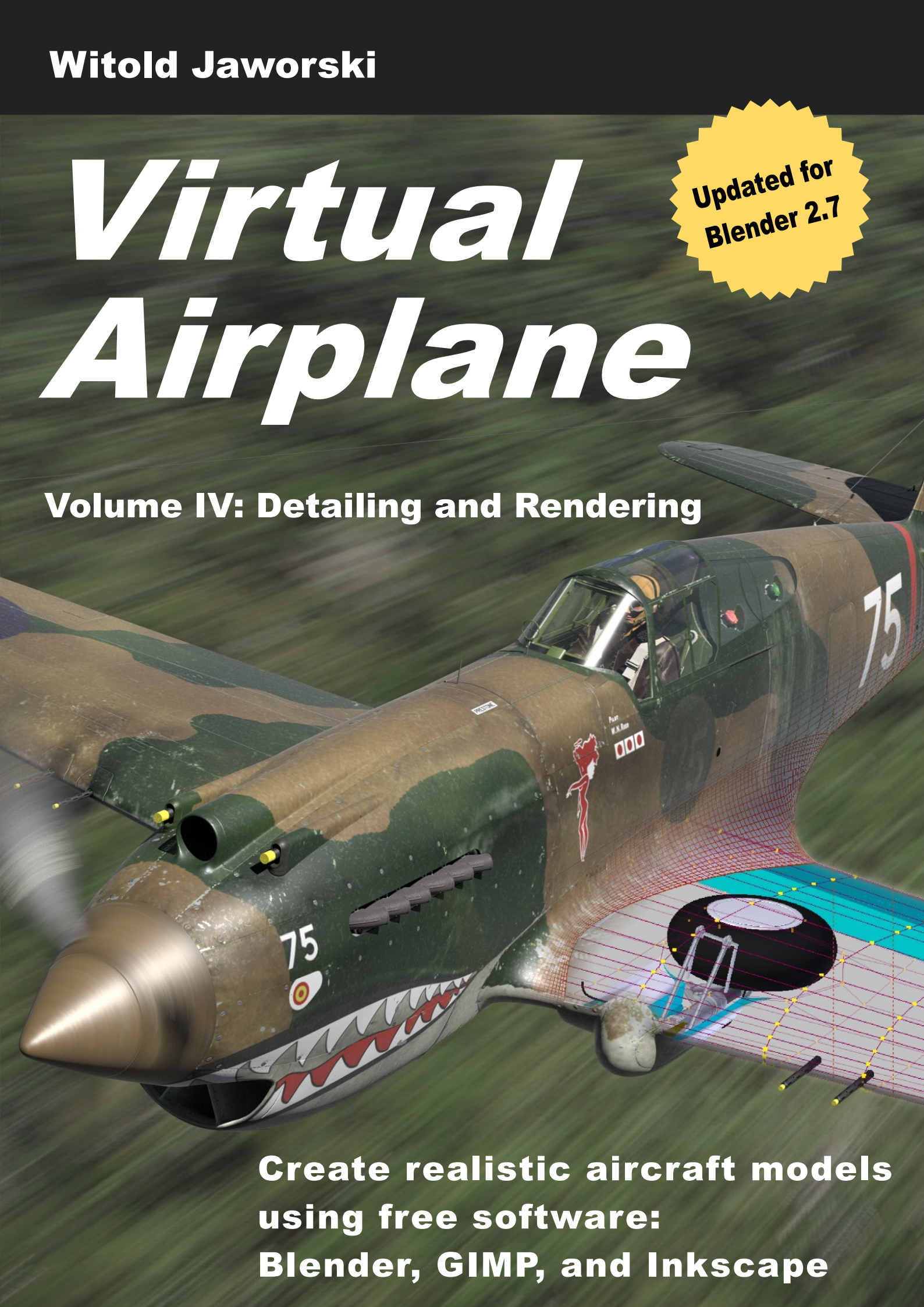
Witold Jaworski

Virtual Airplane

Updated for Blender 2.7

Volume IV: Detailing and Rendering



Create realistic aircraft models using free software: Blender, GIMP, and Inkscape

Virtual Airplane

To my wife
for her forbearance

Witold Jaworski

Virtual Airplane

Create realistic aircraft models using free software: Blender, GIMP, and Inkscape

Third edition

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The picture on previous page:
A pair of P-40B's from 47th USAAC Pursuit Squadron, which managed to take off to fight the Japanese raid on Pearl Harbor, on 7th December, 1941. They were piloted by Kenneth Taylor and George Welch.
At that time 47th PS was practicing gunnery at Haleiwa, a secluded field on the North East corner of Oahu Island. This area was not attacked by Japanese airplanes (Pearl Harbor lies on the opposite side of the Island). The runway ran along the sea coast. This is how the fighters might have appeared shortly after taking off. The background is based on an authentic part of the shore near Haleiwa. *Creation of this scene is described in the last sections of this guide .*

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Why I wrote this book

Because I always wanted to create a detailed model of an airplane on the computer. When I finally did it — it proved to be great fun! So I decided to share this experience with others.

A long time ago I was an ordinary modeler, making scale aircraft models. It is a specific hobby. We work hard for many months on our projects. We try to engrave tiny rivets, skin panels, and fine details of the cockpit instruments on our small model. An external observer can conclude that anglers spend their time in a similarly monotonous, but less tiring way. What's more, instead of creating nice, shiny miniatures, we apply to their surfaces (horror of horrors!) trails of dirt and abrasion, to create the impression of intensive usage. We blemish them to look like real, worn, and in some places rusted, machines. Our reward is to show our work to someone who can appreciate its finesse (this can happen from time to time). Strangely enough these evaluators are usually other modelers. Maybe it is just a pretext for the opportunity to discuss such esoteric topics as the superiority of the Spitfire IX over the FW 190 A4? Or the hot issue, how was the P-40K from 23rd FG painted, in which Witold Urbanowicz flew his combat missions over China in 1943?

I would like to offer fellow modelers entirely new materials and tools. Instead of your own desk, sometimes covered with spots of airbrush splashes — a window to another world, in the depths of the computer screen.

In this virtual world you will find an elastic material that can be extruded into any shape. What's more — you will never run out of it! There are paints, for which you can precisely set the colors, shininess, and other properties. It is possible to achieve accuracy there that you cannot get anywhere else, neither in 1:24 nor in 1:18 scale. When you find out that the engine cowling of your old model should have a different shape, you can always correct this error. You can update it many times! Dust will not cover your computer models. You will never hear complaints from your family that there is no place for your growing collection. You can also create many variants of your airplane (each of them in a different camouflage, for example). Your models can be sent to other hobbyists like yourself, without fear that something will happen to them during transport. You can also quickly build up a whole scene, using your planes.

The only thing you have to get used to, is that you cannot touch anything in this virtual world. You can only select visible objects with the mouse. More advanced haptic devices are still expensive and primitive, at least at the present stage of the technology development. On the other hand, we currently observe fast development of inexpensive 3D printers. I expect that in the near future you will be able to print on these devices parts of your computer models.

This world of virtual modeling sneaked into reality in the middle of the past decade. In fact, every computer produced after 2005 is a fully equipped graphics workstation. (You could only dream about such a computing power in the previous century). In 1997 a new mathematical model for surface modeling entered the scene. It is called "subdivision surfaces" (or, shorter: "SubD"). This technology allowed the first computer animation studios (like Pixar) to create Shrek and dozens of other cartoon characters. In the future, subdivision surfaces may replace the older NURBS solution in CAD/CAM systems. Using the SubD you can create very complex shapes (like a whole dinosaur, or complete engine block, for example). This mathematical tool copes well with holes and cutouts. (Such features are not "natural" for the NURBS surfaces. The NURBS-based CAD/CAM systems still have troubles with special cases of fillets and holes. They were programmer's nightmare).

What's more, software which uses all these technologies became available for free! It has been created by hundreds of Open Source programmers. These people want to show that they can be at least as good as their best commercial counterparts, and they have begun to achieve it! Maybe they are driven by the pure intellectual challenge ("I'll do it better!"). Such volunteer projects have also a different pace of coding: there is no rush in this work. On the contrary, tight schedules are always present in typical commercial enterprises. These deadlines are the primary cause of many errors. In effect, a large enough group of enthusiasts (in Open Source they often call it "the critical mass") can create a good, stable program.

To sum up — buying an ordinary computer for games, you have bought everything you need to enter the new world of virtual modeling. I will not cheat you: one inherent thing in the work of every modeler is still present here. Creation of an accurate computer model requires several weeks of hard effort, just like its real-world counterpart. However, I wrote this book to help you, dear Reader, in reaching the desired results faster. Then you can go ahead and do the same thing even better than I suggest here. Reading the following pages will save you a lot of time, and — sometimes — plenty of frustration. The latter is usually an integral component of working with “this stupid machine”: the computer. I will try not to bore you, and will show plenty of pictures. I hope that you will find this book interesting.

Witold Jaworski

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What this book covers

"Virtual Airplane" teaches you how to create the model, shown on the cover page. The complete book was too large not only for printing, but also for the typical e-book distribution channels (as Amazon or Apple iBookstore). Thus I decided to split it into volumes associated with the subsequent phases of the work. They are: "Volume I: Preparations", "Volume II: Modeling", "Volume III: Materials and Textures" and "Volume IV: Detailing and Rendering". I chose for this book the Curtiss P-40B fighter as the exemplary airplane. Its design contains typical features used in most aircraft of this period. I chose it because I do not want to deprive you the pleasure of building models of the famous fighters such as the Spitfire, Mustang, Thunderbolt, Focke-Wulf, or the Messerschmitt!

- You can use the methods presented in this book to create any Second World War fighter[1] model. It does not have to be the P-40, as all of these airplanes had a similar design. In the course of this work you will encounter most of the modeling problems, both described and solved here.

"Virtual Airplane" is intended for those who are just beginning their adventure in the "3D", as well as for those, who have already some experience on this field. Therefore, I decided to divide it into two parts:

- the first part ("Creating the Model") contains the main text, which describes **what** you should do;
- the second part ("Details of Programs Usage") contains detailed descriptions of **how** to use particular software to obtain the results shown in the first part.

The pages of "Details of Programs Usage" span over half of this book. The contents of this second part resembles a context help scheme. It contains plenty of short sections (one or two pages per section), containing no more than a few illustrations. Each of them describes details (keyboard shortcuts, menu commands, results) of a single operation.

Dividing the material of this book between the basic and detailed part, I tried to avoid excessive details in the main text, like "click this button, select this item". Such hints, although needed, make the narration longer and obscure. In the first part, where appropriate, I placed links to the second part of this book. If you are new to the program which is used in the main text, just follow these links to the detailed descriptions of every operation[2]. I prepared chapters of the main text in a sequence that will let you gradually learn all of these tools. Once you know **how** to do what I am describing — just stop using these shortcuts.

This book also has a third part: "Appendices". These additional chapters contain a "hodgepodge" of many different articles: discussion of some optic phenomena (like barrel distortion of the image on a photograph, or the light refraction), a color theory for CG, and an airfoil geometry details. This part also contains a review of advanced methods for blueprint verification (on the level that allows you to create improved scale plans), and details of subdivision surfaces mathematics. All of these materials are optional, although I think that they may help you in better understanding some issues mentioned in the main text ("Creating the Model").

[1] Well, at least those which used inline engines. I have not described here how to model the externally visible components of air-cooled radial engine. All these cylinders, rods and tubes... Maybe I would include a P-36 model, in the next edition of this book?

[2] I assume that the use of the second part will always be random. Thus most of its basic sections contain text without further references. This approach means that, for example, the description of the scaling in Blender *Mesh Editor* is almost a verbatim copy of the description of similar operation in the *Object Editor*. They differ only in the illustrations and a few sentences. I just do not know which of these topics you will open as the first one, so each of them provides all the information you need.

Conventions

For the tips about using the keyboard and the mouse I have assumed that you have a standard:

- US keyboard, with 102 keys (you will find in this book some comments about non-standard laptop keyboards);
- Three-button mouse (in fact: two buttons and the wheel in the middle. When you click the mouse wheel, it acts like the third button).

Command invocations are marked as follows:

Menu→Command	means invoking a command named *Command* from a menu named *Menu*. More arrows may appear, when the menus are nested!
Panel:Button	means clicking a button named *Button* in a dialog window or a panel named *Panel*. Panels are parts of Blender screen (for more explanation — see „Volume II: Modeling"). Sometimes I may also mention other dialog controls, like a checkbox or a drop-down list.

Pressing a key on the keyboard:

Alt-K	the dash ("-") between characters means that both keys should be simultaneously pressed on the keyboard. In this example: while holding down the Alt key, press the K key;
G, X	the comma (",") between characters means, that keys are pressed (and released!) one after another. In this example type G first, then X (as if you would type "gx").

Pressing one of the mouse buttons:

LMB	left mouse button
RMB	right mouse button
MMB	middle mouse button (mouse wheel **pressed**)
MW	mouse wheel (when it is **scrolled**)

Last, but not least — the formal question: how should I address you? The impersonal form ("something is done") is used in most of the guides. I think that it makes the text less comprehensible. To keep this book as readable as possible, I address the Reader in the second person ("do it"). Sometimes I also use the first person ("I've done it", "we did it"). It is easier for me to describe my methods of work in this way[1].

[1] While working on this model I thought about us — you, dear Reader, and me, writing these words — as a single team. Maybe an imaginary one, but somehow true. At least, writing this book I knew that I had to properly explain to you every topic, with all details!

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How to read this book

This guide is a digital publication. To make it more readable than a classic book, I moved most of the detailed instructions out of the main text, leaving their hypertext references. Use them for “digging into details” and then jump back to the general subject. To avoid “cluttering” the text, these links are not distinguished either by the color or by underline. You can recognize them by the context (“see page …”) and the behavior of the mouse pointer. When you hover over a link, its shape changes into a “pointing hand” (Figure 1.1.1):

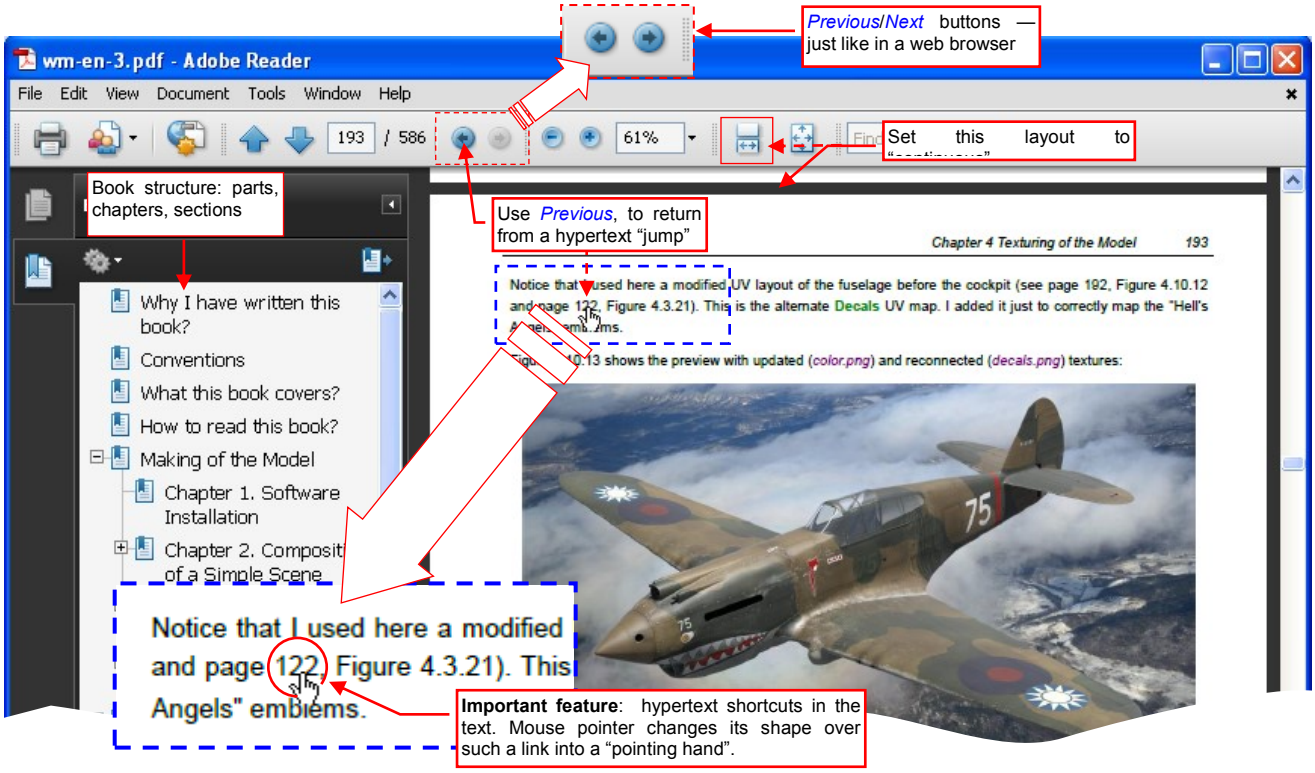

Figure 1.1.1 Reading this book in a PDF reader (Adobe Reader)

Click the link, to go to the referenced page. To return to the previous location, use the ***Previous*/*Next*** buttons. In Figure 1.1.1 they are located on the toolbar at the top of the screen, and work just like in the web browser. To make subsequent pages more readable in your PDF reader, you can also switch their display mode to “continuous” (Figure 1.1.1). I think that this mode is better for online reading.

I tried to make this PDF document as portable as possible, thus I published it in so-called PDF/A format (it contains embedded fonts and color information). Be aware that the popular **Adobe Reader** by default ignores all hypertext links in such files (Figure 1.1.2):

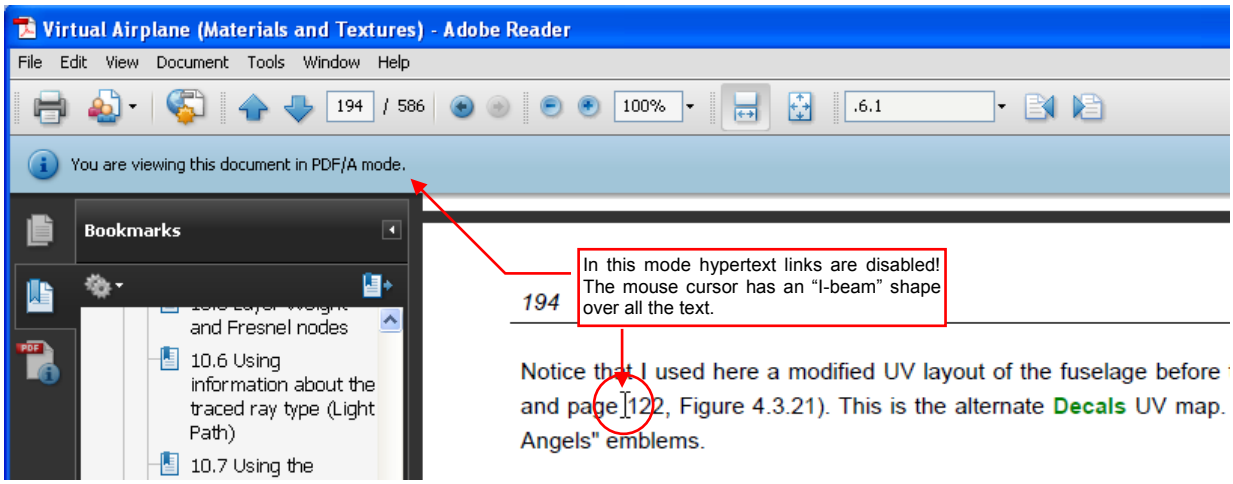

Figure 1.1.2 Inactive hyperlinks in the PDF/A mode (Adobe Reader).

To enable hypertext links in a PDF/A document, you have to change **Adobe Reader** *Documents* settings (Figure 1.1.3):

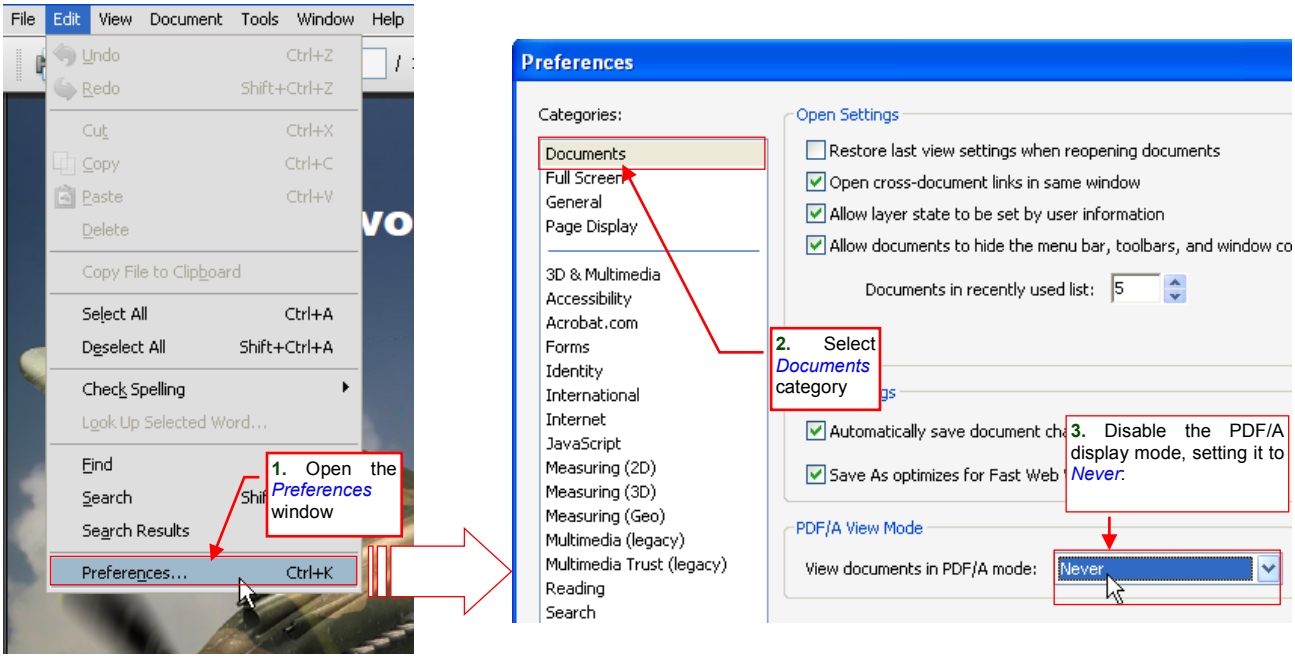

Figure 1.1.3 Enabling hypertext links for this document (Adobe Reader, version 9.0)

Open the ***Preferences*** dialog window from the ***Edit*** menu. Select ***Documents*** on the category list. This brings up appropriate controls on the right side of the window, as shown in Figure 1.1.3. Disable the *PDF/A View Mode* selecting ***Never*** from its drop-down list.

Subsequent versions of **Adobe Reader** differ from each other. For example their toolbar may appear at the bottom the screen (as it happened to the version 8.0). What's more, the *Previous*/*Next* buttons, useful during the hypertext “jumps”, may be absent in the default configuration of this program (Figure 1.1.4):

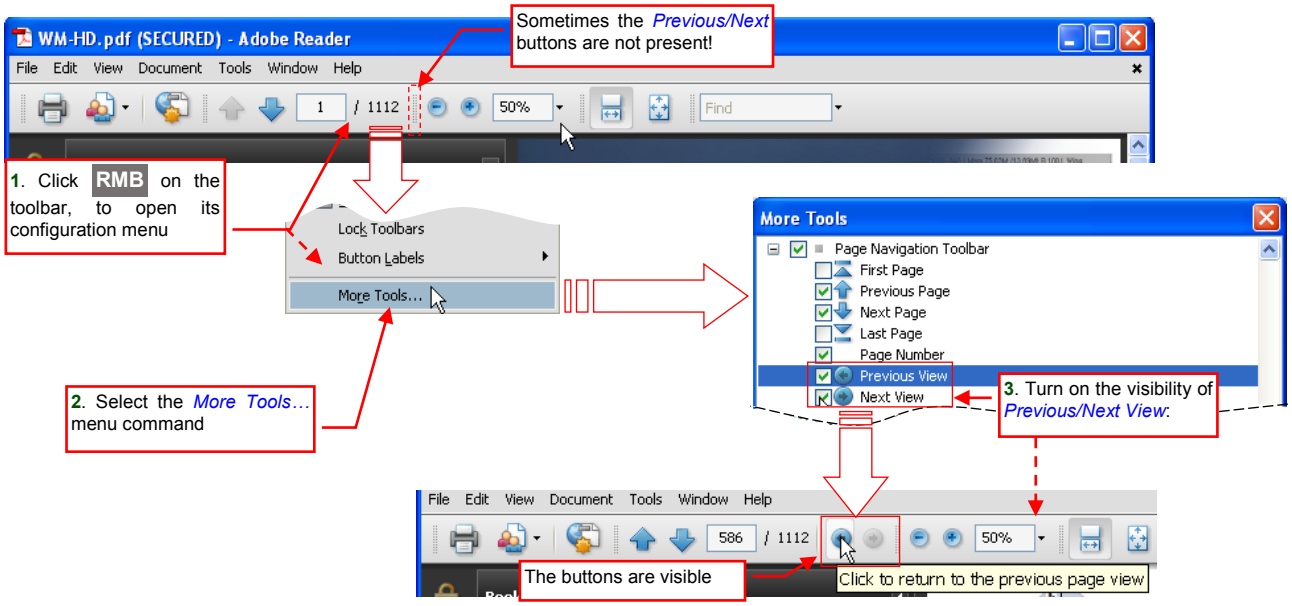

Figure 1.1.4 Adding the *Previous/Next* buttons to the toolbar (Adobe Reader).

Although you can always use the keyboard shortcuts (*Previous*: Alt - ←, *Next*: Alt - →), it is always better to see these buttons. Click RMB on the toolbar, to pull down its context menu, and invoke from it the *More Tools…* command. In the *More Tools* window find and mark the ***Previous View*** and ***Next View*** items. It will bring the buttons back to the toolbar (Figure 1.1.4).

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In this book, illustrations are very important. You can find them on almost every page. (Actually, this guide can be described as a partial “comic book”). Unfortunately, their presence significantly increases the PDF file size. To keep it to a reasonable level, I had to turn on image compression, which decreases the quality (especially the vivid red color of the model materials). What you see is the result of a compromise between the file size and the accuracy of the pictures it contains. For **Adobe Reader** I would suggest altering a few parameters which can improve the quality of these illustrations. They are not set by default, so you will have to change them manually in the configuration of this program (Figure 1.1.5):

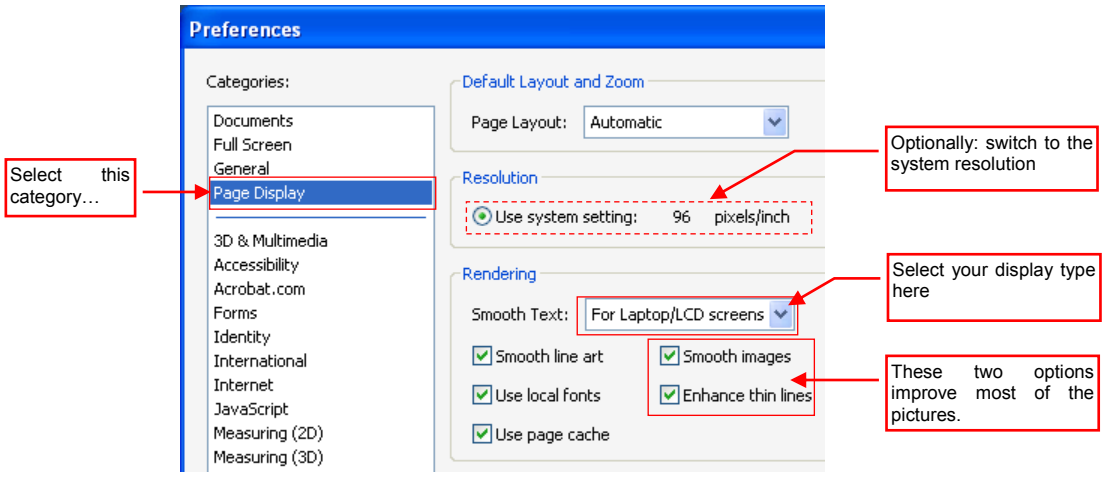

Figure 1.1.5 Optional settings, to improve the display quality of document images (Adobe Reader version 9.0)

In the *Preferences* dialog select from the list the ***Page Display*** category. This brings up appropriate controls on the right side of the window, as shown in Figure 1.1.5. Select the appropriate text smoothing method from the ***Smooth Text*** list. (The *Monitor* mode is selected by default). Perhaps you are using a kind of LCD computer display. In such case you should select the ***For Laptop/LCD screens*** option.

In addition, in the *Resolution* area you can also select the ***Use system setting*** option. (The other option — *110 pixels/inch* — is selected by default). Personally, I think that the pictures look better in this “system resolution”[1]. Do not worry if in your program you can see a different value than the 96 pixels/inch (Figure 1.1.5). It depends on the text size, which you have set up in your Windows system settings.

Finally, in the *Rendering* area there are two check boxes: ***Smooth images*** and ***Enhance thin lines***. In most cases you should keep them turned on (as in default settings). However, if the airplane on the cover image of this book has slightly wavy edges on the wings, you can try to disable these image anti-aliasing settings. Decide yourself, whether it looks better without these options.

* * *

You may always print a copy of this book for your own use. However, it is also possible to read it directly from the screen, while working on the model. In the latter case you can save some paper, preserving a few more trees in this way. What’s more, you will have all the detailed descriptions at hand, through the hypertext links.
Of course, if you prefer to page through a traditional, paper book — print all its pages[2]. Even if your printer supports duplex printing, you have to prepare an entire ream of A4 sheets for the full book! I assure you that this was not my intention ☺.

* * *

[1] In this resolution the letters are somewhat smaller. It is especially obvious in the callouts, placed on the images!

[2] This e-book contains all pictures in color. Therefore, many of them will have a low contrast in the print. As a remedy for this effect, I changed the color of callouts on some illustrations to darker or lighter one. It makes them to look better, when they are printed on a monochrome printer.

"Virtual Airplane" is also available in other popular eBook formats: **EPUB** and **MOBI**. However, **PDF** is the best format of this book for **Android** tablets (in this form it is available on Google Play)[1]. As the reader program on this platform I also recommend **Adobe Reader** (Figure 1.1.6):

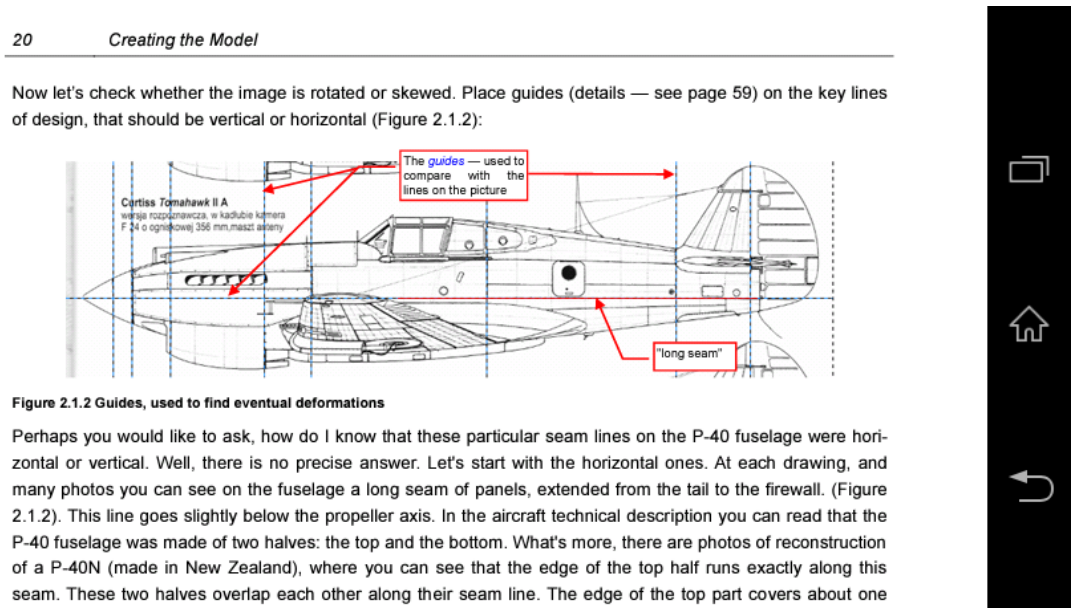

Figure 1.1.6 Reading this book on Android **tablet (in** Adobe Reader**, version 11)**

Comparing to the PC version (presented earlier in this section), this **Adobe Reader** has a simplified user interface and a minimum number of options (Figure 1.1.7):

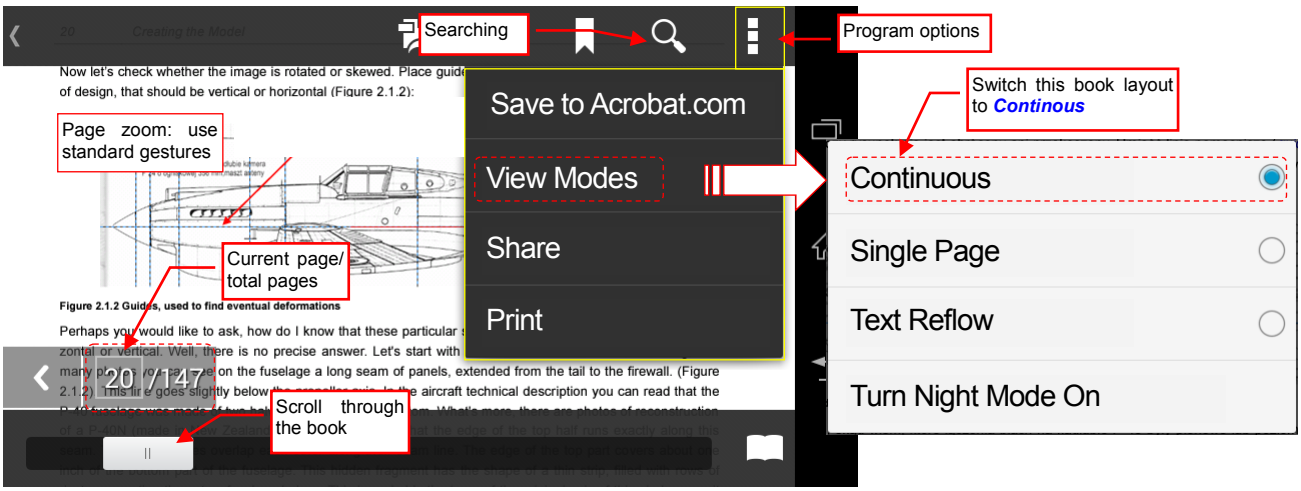

Figure 1.1.7 Adobe Reader **user interface (**Android**)**

Fortunately, you can still set here a continuous page layout (***View Modes→Continuous***, see Figure 1.1.7). This option is especially useful for displays of smaller size.

[1] **MOBI** is a proprietary book format of Amazon.com. In principle, **EPUB** is an open format supported by most readers. However, "in principle" does not mean "always". When I was looking for an EPUB-reader which I could recommend for tablets running **Android,** I think I tried most of the free apps that I found on Google Play. No one of them displayed properly the **.epub* file of this book. Why? The contents of a typical e-book is displayed as so-called flowable text. An e-book reader fits these paragraphs into available screen area (in a similar way as web browser fits contents of web pages into its window). The "Virtual Airplane" illustrations contains a lot of explanations. To easily read this book, the font size of these explanations should be unified across whole text. To provide this effect, illustrations had to dynamically fit to a reader screen. Although I use for this purpose a method (style) documented in the EPUB 3.0 specification, it turns out that many of readers, especially those for **Android** system, cannot cope with this effect. In this situation, I decided to deliver this book in the **EPUB** format only to **iPad**s (via Apple Store, optimized for the popular **iBooks** reader) and PC. I do not want to deliver it to other devices in a format that may be incorrectly displayed.

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In this “mobile” **Adobe Reader** you can also use the internal hypertext links. However, on the touch screens of **Android** devices there is no cursor which changes shape over such a link. Keep in mind that every reference to a page number, figure or chapter contains such a reference. Just tap the relevant text (Figure 1.1.8):

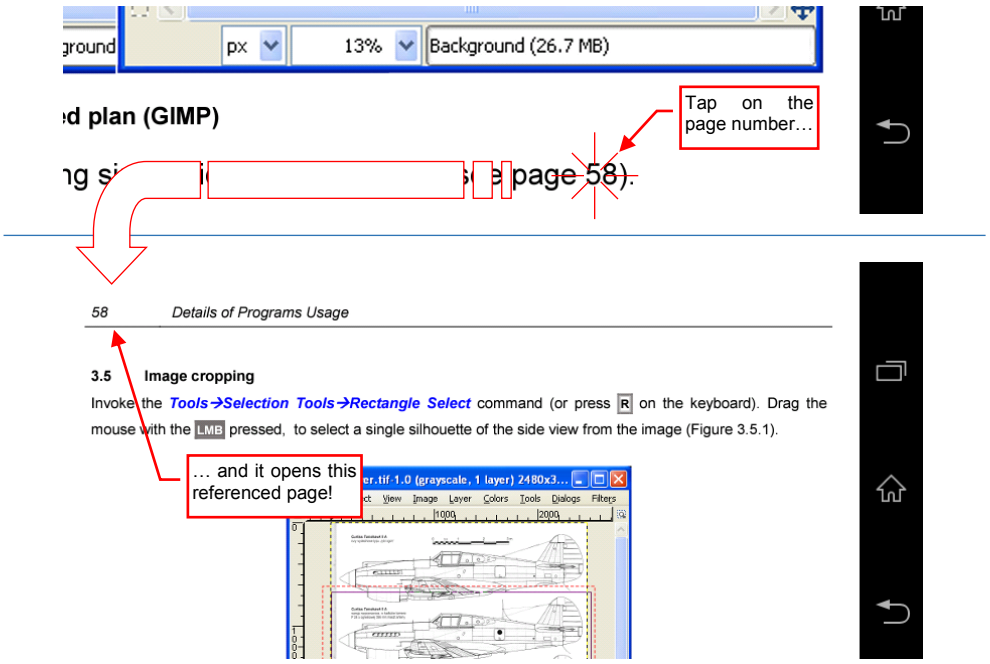

Figure 1.1.8 Using the internal hypertext references

To return from such a “hypertext jump” to the previous location, use the “<” button, which appears on the right (near the page number — Figure 1.1.9):

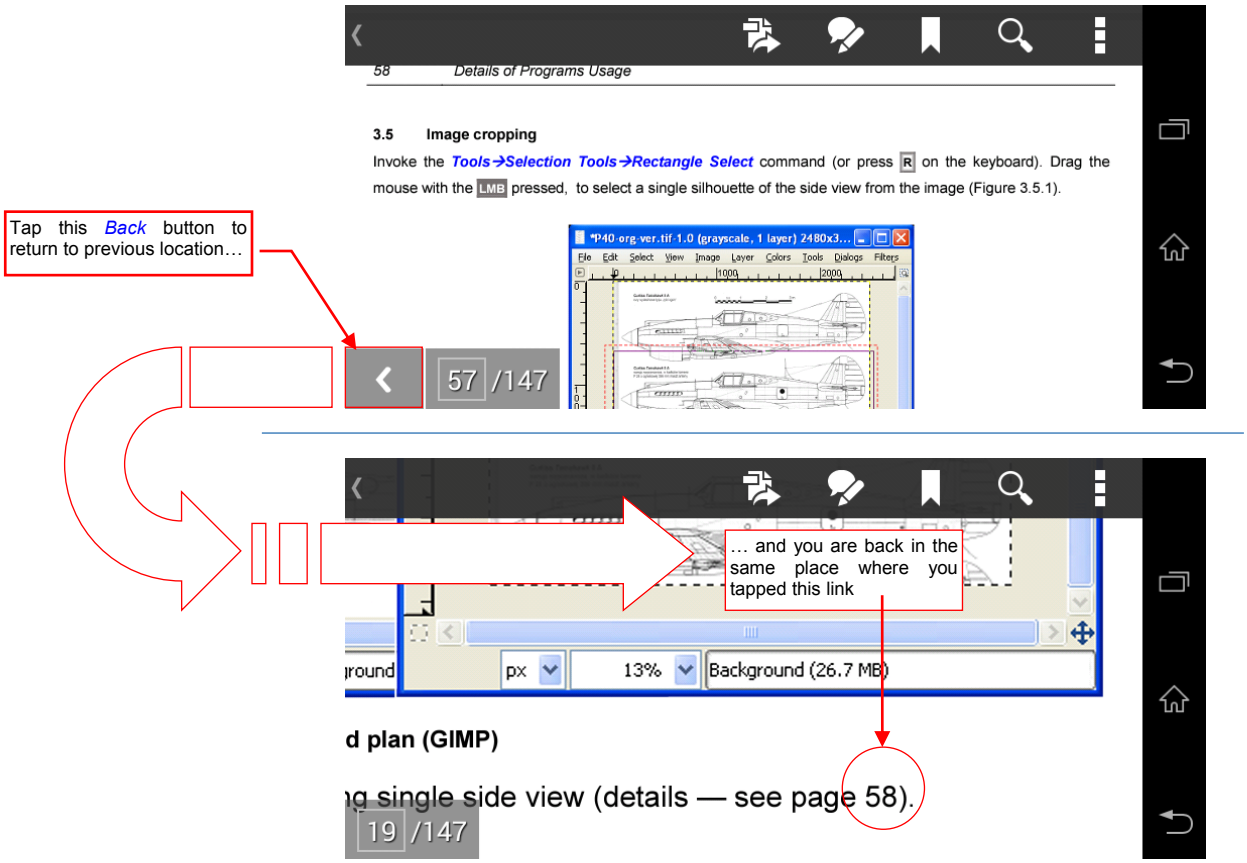

Figure 1.1.9 Returning from referenced page

- **Adobe Reader** for iOS (**IPad**) has no *Back* button, which makes it practically useless for this book.

In the 20th century you could make an aircraft model from paper or plastic. In the 21st century the time has come for yet another variation of this hobby: computer models. The birth of this new branch of scale modeling was unnoticed. Few people could spend several thousand dollars of their private money buying a complete 3D design environment just for amusement. In the first years of this century the only alternative was the use of an “inappropriate” software — nothing to boast about... So the first enthusiasts were quietly sitting at their monitors and creating models, learning from their own mistakes.

The times are changing, and now all the necessary software is available for free (it is GPL-licensed). So if you bought your computer less than 6 years ago, you have everything you need to get started! This book provides the essential know-how. I will show you step by step, how to make such models as the P-40 shown on this cover.

“Virtual Airplane” was written not only for the scale modelers. It may also be useful to all who want to learn the three most popular Open Source graphic programs: Blender, GIMP, and Inkscape.

Visit **www.airplanes3d.net** to ask a question or obtain free trails!

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A P-40B from the 3rd squadron of AVG („Hell’s Angels”), Kunming 1942. (Background photo: © Tomo Yun, *www.yunphpto.net*)