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Computer Methods for Investigating CV *Taihô*

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Abstract

The author is in the process of writing a book tentatively titled *Anatomy of the Ship: The Fleet Aircraft Carrier Taihô*." This project has involved a number of computer methods to categorize, illustrate, translate and postulate facts and data found in historical records.

This paper will show how simple computer methods like tables and lists can identify previously unnoticed historical details. It will also be shown how popular drawing programs such as Adobe Illustrator can identify and correct errors in plans of warships. The author will explore the use of 3D visualization software and how it can add realism to warships lost in battle and nearly lost to history. It will be shown how 3D drawing software can also confirm details such as ship displacements under varying loads.

Introduction

Between 1939 and 1944, the Japanese Navy designed and built their most advanced aircraft carrier, *Taihô*. Within 3 months of her completion, this ship was destroyed in battle from a massive aviation gasoline explosion after a single torpedo impact. As the Pacific war ended, most of the technical information, plans and operational details for *Taihô* were destroyed either by Allied bombing or by the Japanese military itself. Some technical documents were collected by the Naval Technical Mission to Japan immediately after the war's end and copies of much of this material is available in the U.S. National Archives [i]. But many of the materials inventoried and indexed by the Naval Technical Mission were subsequently lost. These various events or circumstances have resulted in a scarcity of information and in many questions regarding this shi This paper discusses the use of computer methods to verify the remaining details and to extrapolate this scant and often conflicting information into detailed plans. The intent is not to explain how to use various computer programs but rather how these programs can help in the investigation of naval history. The examples draw on the author's own experience and on the work of colleagues. The techniques and examples are categorized by the following classes of computer applications:

- tables and lists
- drawing software
- imaging programs
- 3D visualization software

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- internet access and sites

As an aside, please consider a leading source for records and evidence pertaining to naval history. The U.S. National Archives is an amazing repository. But the thing that is so challenging about NARA is that one can find just about anything if you can only provide the index information. The encyclopedic volumes filled with abbreviated index titles fill entire rooms. And although NARA staff has started the enormous task of computerizing this index information, the light at the end of that tunnel is not yet visible.

The whole experience has pushed me to predict what records might exist and where they might be stored and then to try to find them. I call this the needle in the haystack problem. If you can't define or describe the needle, you'll never find it in the haystack of historical records. This is the concept that I'm using in my *Taihô* research. I propose a reasonable theory based on known facts and then go looking for the proof. Some of the computer methods presented in this paper have resulted in answers but even more often they present an idea in want of supporting evidence, a picture of a needle to be found in the haystack.

Tables and lists

Lists are the nucleus of any sort of reporting or record keeping whether the subject relates to naval history or programs on television. Focusing on warship characteristics, one might start by listing all known battleships built or planned. But as additional data is added pertaining to each of the battleships, such as country that built the ship or the size of guns, the list becomes a table. These are ancient methods. But when a computer is utilized to maintain the list or table of information, it becomes possible, even simple, to rearrange the information in a way that might yield valuable insights.

Example: IJN ship building data

There are a number of references available that contain data about each warship built by the Imperial Japanese Navy. Such a book is "The Imperial Japanese Navy" by Anthony Watts and Brian Gordon [ii]. This book is notable for its Appendix I which lists the Japanese ship building programs from 1937 onward, with the order of the data first by building program and then by ship order number. The ship order number is very useful because it tends to be very sequential and is intuitively useful for a computerized list. But this book as well as many others also contains additional detailed data for each warshi As a starting point for familiarization with the ships of the Japanese Navy, it is useful to record such details as building yard, start date, launch date, and completion date as well as the basic data of ship name, type, class, and so on. The following table is a representative sample from such a computerized list, created using a spreadsheet.

Order No.	Type	Class	Ship Name	Builder	Laid Down	Launched	Completed
1	BB	Yamato	Yamato	**Kure NY**	11/04/37	08/08/40	12/16/41
2	BB	Yamato	Musashi	**Mitsubishi DY**	03/29/38	11/01/40	08/05/42

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2	BB	Yamato	Musashi	**Mitsubishi DY**	03/29/38	11/01/40	08/05/42
3	CV	Shôkaku	Shôkaku	**Yokosuka NY**	12/12/37	06/01/39	08/08/41
4	CV	Shôkaku	Zuikaku	**Kawasaki DY**	05/25/38	11/27/39	09/25/41
:	:	:	:	:	:	:	:
110	BB	Yamato	Shinano	**Yokosuka NY**	05/04/40	10/08/44	11/19/44
111	BB	Yamato	–	**Kure NY**	11/07/40	–	–
:	:	:	:	:	:	:	:
130	CV	Taihô	Taihô	**Kawasaki DY**	07/10/41	04/07/43	03/07/44
132	C	Agano	Agano	**Sasebo NY**	06/18/40	10/22/41	10/31/42
133	C	Agano	Noshiro	**Yokosuka NY**	09/04/41	07/19/42	06/30/43
134	C	Agano	Yahagi	**Sasebo NY**	11/11/41	10/25/42	12/29/43
135	C	Agano	Sakawa	**Sasebo NY**	11/21/42	04/09/44	11/30/44
136	C	Oyodo	Oyodo	**Kure NY**	02/14/41	04/02/42	02/28/43
:	:	:	:	:	:	:	:
300	C	Ibuki	Ibuki	**Kure NY**	04/24/42	05/21/43	–
301	C	Ibuki	Ikoma	**Mitsubishi DY**	06/01/42	–	–
302	CV	Hiryu	Unryu	**Yokosuka NY**	08/01/42	09/25/43	08/06/44
:	:	:	:	:	:	:	:
1001	CV	Junyo	Junyo	**Mitsubishi DY**	03/20/39	06/26/41	05/03/42
1002	CV	Junyo	Hiyo	**Kawasaki DY**	11/30/39	06/24/41	07/31/42
:	:	:	:	:	:	:	:
5001	CV	Ikoma	Amagi	**Mitsubishi SB**	10/01/42	10/15/43	08/10/44
5003	CV	Ikoma	Katsuragi	**Kure NY**	12/08/42	01/12/44	10/15/44
5004	CV	Ikoma	Kasagi	**Mitsubishi SB**	04/14/43	10/19/44	–
5006	CV	Ikoma	Aso	**Kure NY**	06/08/43	11/01/44	–
5007	CV	Ikoma	Ikoma	**Kawasaki DY**	07/05/43	11/17/44	–

Of course, this table shows slices from a more complete list of data. Even with this shortened sample, there is not much in the way of surprises that jump out of the report. Three of the four Agano class cruisers (numbers 132, 134, and 135) were built at the Sasebo Navy Yard. Because these ships are in a close sequence in the list, it is noticeable that the start and launch dates for these ships do not overlap with each other and in fact have a reasonable space of 20 and 26 days between the launch of one ship and the start of another. There is a strong implication from this observation that these ships were likely built in sequence on the same sli This begs the question of other sequences of ships constructed one after the other. This question becomes very relevant if one considers that any delays in the construction of one ship up through its launch could impact the start and therefore the completion of the next ship in the sequence.

The characteristic of computerized lists and tables that is so important to the study of naval history is that the data can easily be reordered based on a component of the data. If this table is sorted first by the building shipyard and then by the date that the ships were laid down, the resulting table could present other relationships between the ships being built. Consider the

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following reordered table:

Order No.	Type	Class	Ship Name	Builder	Laid Down	Launched	Completed
4	CV	Shôkaku	Zuikaku	**Kawasaki DY**	05/25/38	11/27/39	09/25/41
1002	CV	Junyo	Hiyo	**Kawasaki DY**	11/30/39	06/24/41	07/31/42
130	CV	Taihô	Taihô	**Kawasaki DY**	07/10/41	04/07/43	03/07/44
5007	CV	Ikoma	Ikoma	**Kawasaki DY**	07/05/43	11/17/44	–
:	:	:	:	:	:	:	:
1	BB	Yamato	Yamato	**Kure NY**	11/04/37	08/08/40	12/16/41
111	BB	Yamato	–	**Kure NY**	11/07/40	–	–
136	C	Oyodo	Oyodo	**Kure NY**	02/14/41	04/02/42	02/28/43
300	C/CV	Ibuki	Ibuki	**Kure NY**	04/24/42	05/21/43	–
5003	CV	Ikoma	Katsuragi	**Kure NY**	12/08/42	01/12/44	10/15/44
5006	CV	Ikoma	Aso	**Kure NY**	06/08/43	11/01/44	–
:	:	:	:	:	:	:	:
2	BB	Yamato	Musashi	**Mitsubishi DY**	03/29/38	11/01/40	08/05/42
1001	CV	Junyo	Junyo	**Mitsubishi DY**	03/20/39	06/26/41	05/03/42
301	C	Ibuki	Ikoma	**Mitsubishi DY**	06/01/42	–	–
5001	CV	Ikoma	Amagi	**Mitsubishi SB**	10/01/42	10/15/43	08/10/44
5004	CV	Ikoma	Kasagi	**Mitsubishi SB**	04/14/43	10/19/44	–
:	:	:	:	:	:	:	:
132	C	Agano	Agano	**Sasebo NY**	06/18/40	10/22/41	10/31/42
134	C	Agano	Yahagi	**Sasebo NY**	11/11/41	10/25/42	12/29/43
135	C	Agano	Sakawa	**Sasebo NY**	11/21/42	04/09/44	11/30/44
:	:	:	:	:	:	:	:
3	CV	Shôkaku	Shôkaku	**Yokosuka NY**	12/12/37	06/01/39	08/08/41
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133	C	Agano	Noshiro	**Yokosuka NY**	09/04/41	07/19/42	06/30/43
302	CV	Hiryu	Unryu	**Yokosuka NY**	08/01/42	09/25/43	08/06/44

Indeed, this new ordering does present several hints for further study. The start of the battleship known as hull #111 at the Kure Navy Yard appears to have closely followed the launch of the battleship Yamato by 3 months. While this is not proof that #111 was built on the same slip, it would certainly seem reasonable given the special yard requirements needed to build these mammoth battleships. No records are known to the author that would confirm this relationship between warship order #111 and Yamato and, while such a relationship might not even be relevant, the possibility suggested from the computerized list gives the naval researcher a needle for which to search.

This list also suggests the building sequence of the cruiser Oyodo, cruiser Ibuki (destined to become an aircraft carrier), and the carrier Aso at the Kure Navy Yard as well as the sequence of carrier *Zuikaku*, luxury passenger ship become carrier *Hiyo*, and carrier *Taihô*. This latter series

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was in fact constructed on slip #4 of the Kawasaki Dock Yard and is the classic example as *Taihô* was delayed for perhaps 6 months due to the modification of *Hiyo* prior to launch in her conversion to an aircraft carrier.

Example: Comparison of frames and spacing

The construction of a warship could be described in terms similar to the human spine and ribcage. Frames of structural supports extend at regular intervals from a central keel. The decks and outer plating (skin) add structural stability onto this framework. The number of frames and the distance (spacing) between frames is a key component of the shipbuilder's art and is usually specified in the line drawings of warships.

Taihô is often described as an improved and enlarged *Shôkaku* class carrier. So, in the investigation of *Taihô*, it became useful to itemize the frames and the spacing and to compare this information with the similar data for the *Shôkaku* . For contrast, the same data was included for the smaller carrier *Hiryu*. Since all of these carriers have a similar layout in terms of forward av–gas tanks, munitions storage, boiler rooms, engine rooms, aft magazines, and aft av–gas tanks, in that order, it was useful to group the frame counts and spacings by these compartments. The following table is the result of this comparison.

	Adjusted Hiryu/Unryu						**Shôkaku**						**Taihô**					
	Section	#	Spacing (m)	Length (m)	Σ #	Σ Len (m)	Section	#	Spacing (m)	Length (m)	Σ #	Σ Len (m)	Section	#	Spacing (m)	Length (m)	Σ #	Σ Len (m)
	FP – 52	52	0.60	31.20			FP0 – FP1	2	0.60	1.20			FP – 1	1	0.60	0.60		
	52 – 54	2	0.90	1.80			FP1 – 69	68	0.60	40.80	70	42.00	1 – 54	53	0.90	47.70		
							69 – 82	13	0.90	11.70								
AV gas tanks	54 – 63	9	0.90	8.10									54 – 63	9	0.90	8.10		
	63 – 71	8	0.90	7.20	71	48.30							63 – 70	7	1.03	7.21	70	63.61
Extra AV gas							82 – 97	15	0.90	13.50			70 – 77	7	1.03	7.21		
											28	25.20						
Mags	71 – 88	17	1.20	20.40			97 – 105	8	1.05	8.40			77 – 89	12	1.07	12.84		
							105 – 117	12	1.10	13.20								
Elect. Gen.	88 – 98	10	1.20	12.00			117 – 125	8	1.05	8.40			89 – 98	9	1.07	9.63		
					27	32.40					28	30.00					28	29.68
BR's	98 – 134	36	1.12	40.32			125 – 161	36	1.12	40.32			98 – 134	36	1.12	40.32		
					36	40.32					36	40.32					36	40.32
ER#1 & 2	134 – 136	2	1.11	2.22			161 – 175	14	1.10	15.40			134 – 147	13	1.18	15.34		
	136 – 138	2	0.90	1.80									147 – 148	1	1.16	1.16		
	138 – 146	8	1.20	9.60														
	146 – 148	2	1.10	2.20	14	15.82					14	15.40					14	16.50
ER#3 & 4	148 – 150	2	1.20	2.40			175 – 177	2	1.00	2.00			148 – 163	15	1.18	17.70		
	150 – 152	2	0.90	1.80			177 – 192	15	1.10	16.50			163 – 165	2	1.10	2.20		
	152 – 158	6	1.20	7.20														
	158 – 164	6	1.11	6.66														
	164 – 166	2	1.20	2.40	18	20.46					17	18.50					17	19.90
Mags	166 – 172	6	1.20	7.20			192 – 210	18	1.10	19.80			165 – 177	12	1.17	14.04		
	172 – 180	8	0.90	7.20	14	14.40					18	19.80	177 – 183	6	1.15	6.90	18	20.94
AV gas tanks	180 – 184	4	0.90	3.60			210 – 221	11	0.90	9.90			183 – 191	8	0.90	7.20		
	184 – 190	6	0.80	4.80														
	190 – 192	2	0.60	1.20	12	9.60					11	9.90	191 – 192	1	0.85	0.85	9	8.05
gas tank							221 – 222	1	0.90	0.90								
	192 – 260	68	0.60	40.80	68	40.80	222 – 302	80	0.60	48.00	81	48.90	192 – 282	90	0.60	54.00	90	54.00
	TOTAL			222.10	269	222.10	TOTAL			250.93	282	250.93	TOTAL			252.00	282	252.00

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	TOTAL		222.10	260	222.10	TOTAL		250.02	303	250.02	TOTAL		253.00	282	253.00
				98	80.70				126	97.20				98	93.29
				94	100.60				96	103.92				94	105.71
				68	40.80				81	48.90				90	54.00
				260	222.10				303	250.02				282	253.00

This table could just as easily have been created with pen and paper, but creating it as a spreadsheet made it easy to add intermediate tallies and groupings. Not much could be seen in comparing these numbers. The frame spacing for Hiryu is typically smaller than for the other ships but the number of frames for *Shôkaku* exceeded the number for the larger *Taihô*.

A further summary of frame counts into four basic sections did provide an interesting correlation. These basic sections were spaces forward of the boiler rooms, the boiler rooms, the engine rooms, and spaces aft of the engine rooms. The count summaries for each ship were as follows:

Hiryu	98	36	58	68
Shôkaku	126	36	60	81
Taihô	98	36	58	90

This comparison produces a remarkable relationship between *Taihô* and *Hiryu* and a marked difference between these two ships and the *Shôkaku* class. This is just the opposite of what was expected and offers several new ideas about how the design of *Taihô* resulted as it did. Again, nothing is proved by this exercise but another theory of *Taihô's* design ancestry is suggested. The use and flexibility of the computer software is certainly key to this new revelation.

Drawing software (e.g. Adobe Illustrator)

As noted previously, there are various sets of drawings of carrier *Taihô* that have survived to the present. But as fortunate as we are to have these items, there are problems with the bulk of the materials pertaining to *Taihô* as well as to other ships of the former Japanese Navy. Many of the most widely used drawings of *Taihô* are the effort of Mr. Shizuo Fukui, former Lieutenant Commander and Imperial Navy constructor. At the conclusion of the war, Mr. Fukui worked for the Second Demobilization Bureau and was instrumental in recreating ship plans from the fragmentary records that could be retrieved by the staff of the Naval Technical Mission to Japan [iii]. But while Mr. Fukui's drawings are very important visual records, particularly for *Taihô*, there are technical errors in the details. Furthermore, many of these records have lost details in the preservation process. Some of the deck plans drawn by Mr. Fukui are barely noticeable in the darkened corners of the microfilmed images. Some images are distorted by folds, which were not forced flat for the camera. Straight lines from the originals are curved in the copies. The following image is an excellent example.

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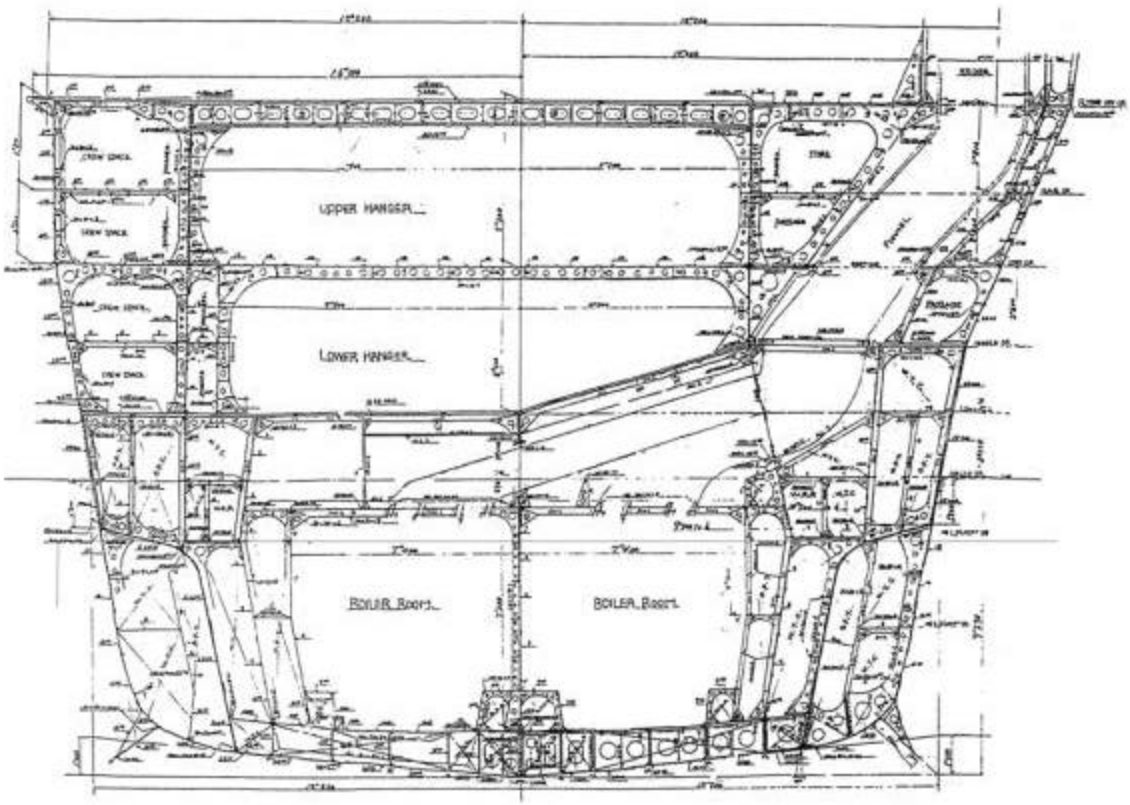

Because this image includes numerous dimensions, it is fairly simple to measure and compare lines that are supposed to be of identical or similar lengths. The hull outline below the waterline should be symmetrical about the centerline but actual measurements show otherwise.

Drawing programs such as Adobe Illustrator allow scanned images to be traced, corrected and enhanced. With some care, the folds captured in copies can essentially be ironed out by tracing segments which can be realigned to correct the defects. Illustration programs also allow many images to be stacked one on top of another and to be viewed together as a Disney cartoonist might have done with animation cells in earlier times. This capability allows the alignment of features that might run vertically from one deck to the next or horizontally from one cross–section cut to the next. These drawing capabilities allow the naval historian to correct defects that have been introduced over time into the historical records.

There is also a situation between the “competing” sets of drawings. In some cases, these drawing sets complement one another. In other cases, the drawings present significant discrepancies. The able researcher needs to use proper care and sound judgment but once decisions are made, the illustration software can be used to consolidate the drawing sets with appropriate considerations.

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Imaging software (e.g. Adobe Photoshop, Adobe Premiere)

Photo imaging software such as Adobe Photoshop provides a number of imaging techniques that can be useful to the naval historian. Two very useful techniques are photo/art overlays and compositing real and imaginary images.

Example: Photo correction/enhancement

The following photo comes from "Carrier Air War in Original WW II Color" [iv]. The picture shows the capsized carrier *Amagi* soon after the war ended. Since the propellers are clearly visible to the right of the photo, this would seem to represent the port side of the shi However, the island and boiler exhaust trunks, both of which were located on the starboard side, are prominent in this view. There is also a question of color, as *Amagi* was known to have been painted with a camouflage pattern that included an olive green color.

Computer imaging software is quite capable of correcting this photo by horizontally flipping the image and correcting the colors. (Note that the color correction was performed by adjusting the mix of the component colors, not by "colorizing".)

The human eye is a marvelous instrument but the process of image recognition seems to work better if the lines of an image run vertical and horizontal. It seemed reasonable that features in the photo might be more easily recognized if the ship could be righted, refloated so to speak.

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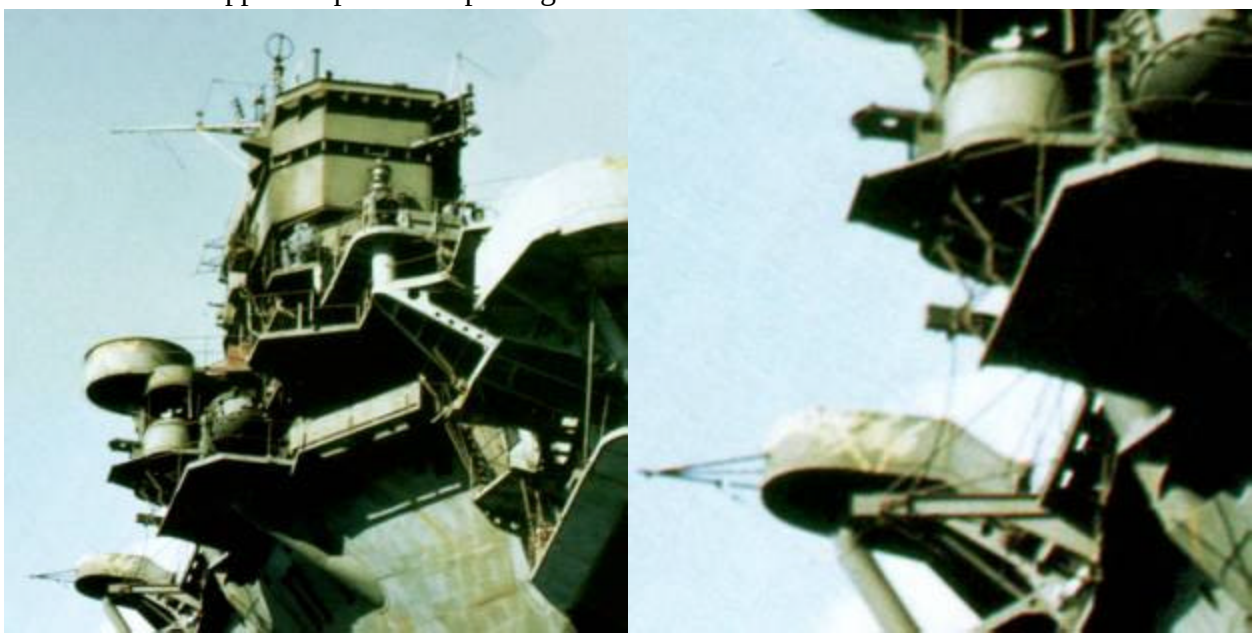
Again the imaging software easily rotated the image. The following picture shows the *Amagi* as she would have appeared prior to capsizing as the result of an Allied air attack.



As expected, details of the rotated image are easier to recognize. It is particularly interesting to notice the gun tub in the lower left of the picture. There appears to be a metal beam tied in place with rope and helping to support the platform. This is possibly an interim repair following an earlier air attack.

Example: Photo/art overlays

The next illustration combines three elements, one of the few photographs of *Taihô*, a line drawing of *Taihô's* lower hangar deck, and a wartime intelligence diagram **[v]**. The diagram, which is on page 87 of the Gakken publication, is from the U.S. Office of Naval Intelligence. This diagram shows a third elevator adjacent to the island and offset to port. At first glance, this seems ridiculous.

However, it is clear that there is something at this location in the photograph that resembles the forward elevator but is perhaps not as wide as the forward elevator. Carrier *Shinano* is known to have had a munitions lift that extended to the flight deck. Perhaps *Taihô* had such a lift as well.

The general accuracy of the ONI drawing which dates to 1944–1945 is surprising. It is also interesting to note that if there had been an elevator in that area of the ship's length and if it extended to the lower hanger, it would need to have been offset to the port side as the lower hanger deck on the starboard side was slanted to accommodate the boiler vents (c vis–à–vis the midsection drawing above).

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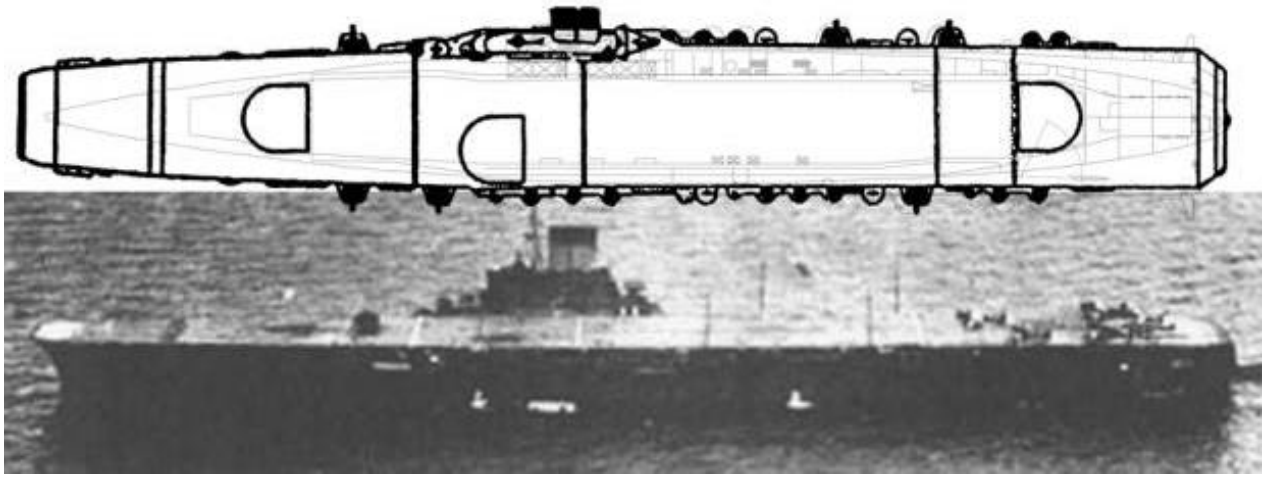

So, could *Taihô* have had some sort of elevator adjacent to the island? If so, what was the function of this elevator? If not an elevator, what might the object in the photo actually be? The use of the computer imaging techniques does not answer these questions but they do support the ONI drawing enough to warrant further study.

Example: Compositing real and imaginary images

"A picture is worth a thousand words." That sentiment applies to the subject of naval history as well as to any other endeavor. But a suitable quantity and quality of photographs are often lacking to satisfy our natural desire to see a historical person or object with one's own eyes. Stylized drawings and paintings often add visual content to naval writings, whether fact or fiction. Photo editing software facilitates merging photographic elements but just as easily supports blending imaginary elements into real scenes. These blended elements could be separate photos of a scale model of a warship or a realistic computer rendering. The following illustration blends a 3–D computer model with a real photograph in which the real ship has been replaced by the model.

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(The point needs to be made in this context that “imaginary” pictures, regardless of the realism, need to be annotated as being imaginary, composite, or “artist’s rendering.” The ability to make an image look real does not make it real and such an image should not be presented as real.)

Example: Photo images from motion pictures

Motion pictures and photographs are typically viewed as separate media formats. But it should be remembered that each second of a movie represents 30 still images. Adobe Premiere is one of many motion picture editing programs. The challenge in the early days of this software class was to digitize the movie for use on the computer. But the difficulty of this process has been greatly simplified by consumer cameras utilizing digitally formatted tapes and the general availability of both cameras and computers with a high–speed digital interfaces such as the IEEE–1394 standard. It no longer requires a professional cinematographer to transfer film formats to a computer format. Once that transfer step is completed, the computer software allows individual frames to be saved as a still picture.

In the case of the Imperial Japanese Navy, there are fewer movies remaining than photographs. But there were several films made by the Allied occupation forces after the war. Since more than a few of the Japanese warships were filmed in their role as repatriation ships, there are archival movies of many of the remaining Japanese warships. The following images were gleaned from motion pictures found in the U.S. National Archives and show postwar images of carrier *Katsuragi*. **[vi]**

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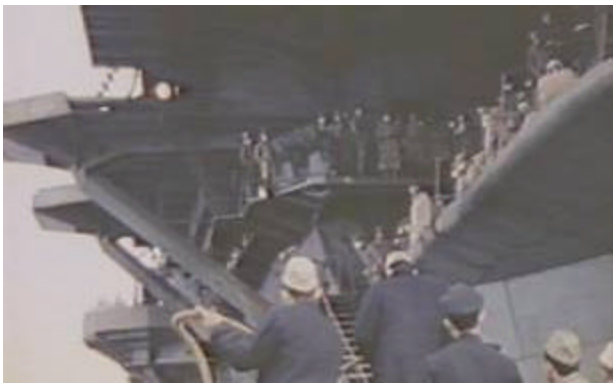

It is worth noting that there are a few computer companies that are pushing a "desktop video" capability. Besides the ability to input video clips into a computer, both Apple and Sony sell systems with a writeable DVD drive and software that simplifies the editing of video materials that can then be written back to a video format on DVD. Look out History Channel; here we come.

3D visualization

The technical ability to merge a representative object, such as a detailed physical model, with a photographic scene has been discussed. But computer technology allows this process to be extended to include representative objects without building a physical model of the object. The "Jurassic Park" series of movies is an example where an object, such as a Tyrannosaurus Rex dinosaur, is "created" within the computer with resulting images that can be blended with live action scenes. **[vii]**

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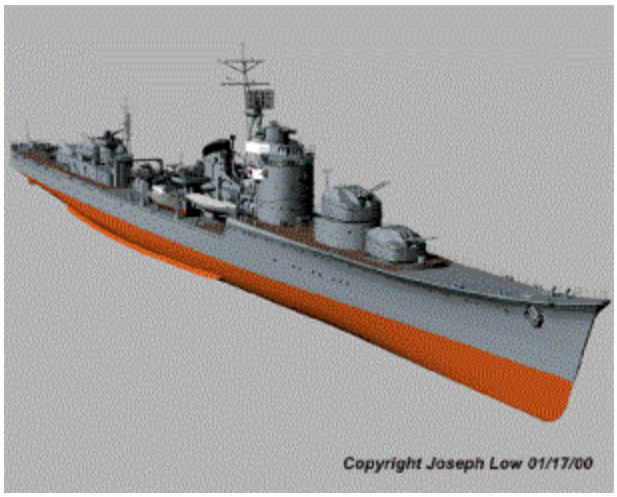
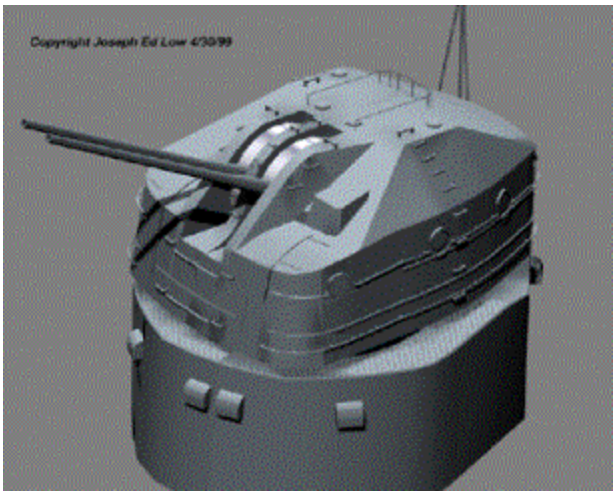
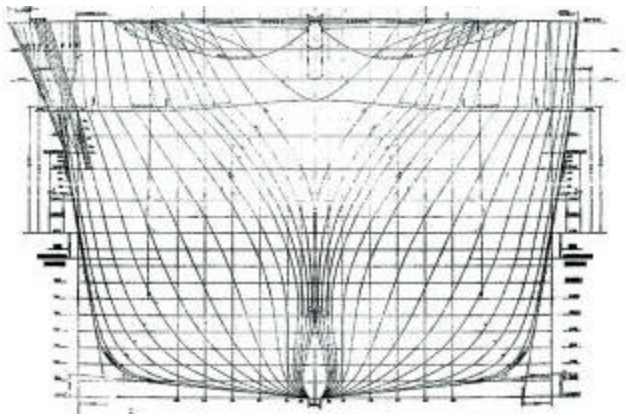


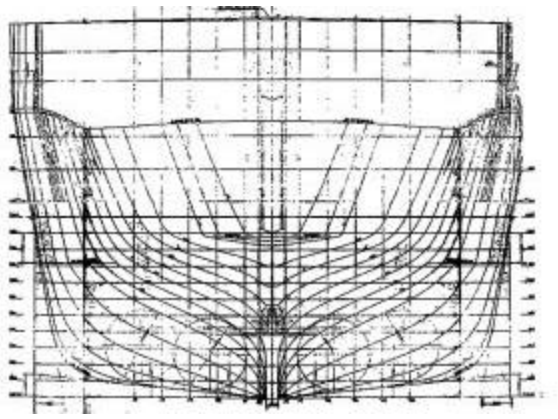


But there are other uses for 3D visualization software beside the obvious ability to "see" an object that no longer exists.

Example: Confirmation/regeneration of plan lines

Besides the general use of 3D software to create realistic images of objects that cannot be easily photographed, there are other capabilities of this type of software. Data sources used to build the geometry of the carrier *Taihô* included archived drawings of the sheer, waterline/breadth, and body plans. These lines yield data points that can be traced in each of three views of the developing 3D model. The following images show some of the lines drawings used in the initial phase of building a 3D model of *Taihô*. [viii]





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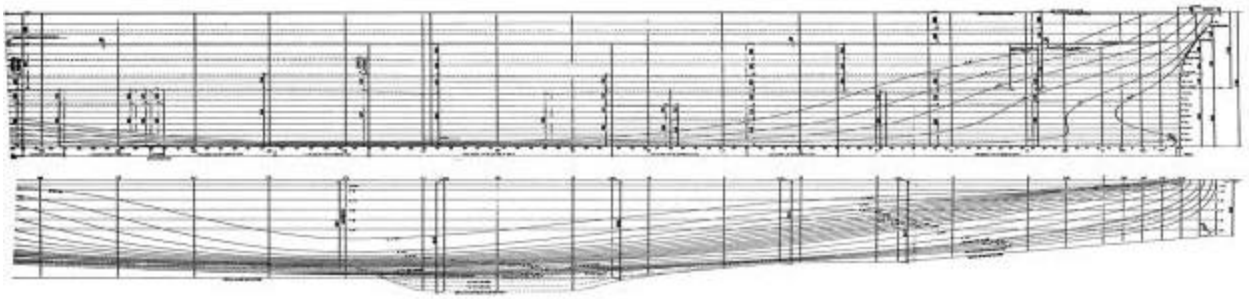

These lines represent the effect of slicing through the ship's hull at regular intervals with the body plans corresponding to the typical method of slicing a loaf of bread, the sheer plan slicing vertically from end–to–end, and the breadth lines slicing horizontally from end–to–end. The promise of this type of slicing and dicing is that the resultant lines can be used to construct the 3D model. However, despite the assumption that these lines drawings could reconstitute the shape of *Taihô*, the reality was quite different. Lines from the opposing views that should have intersected into singular points in 3D space did not. The effort to reconcile these views into a 3 dimensional frame has been the most time consuming aspect of building this model. The good news, however, is that the 3D modeling software has the capability to generate these plan lines. So while the original lines were flawed, they WERE useful in deriving an accurate 3D representation of the *Taihô* hull, which in turn will be used to generate accurate drawings of the sheer, waterline/breadth, and body plans.

Example: Av–gas tank capacity check

The various 3D rendering programs such as AutoDesSys' form*z maintain considerable data about the objects in the computerized model. Besides the typical information regarding the geometry (number of side and edges, location in 3D coordinates) of an object, these programs can calculate and present additional information such as the center of gravity, surface area, and volume with any of these values available in a number of units (e.g. volumes as cubic meters or liters).

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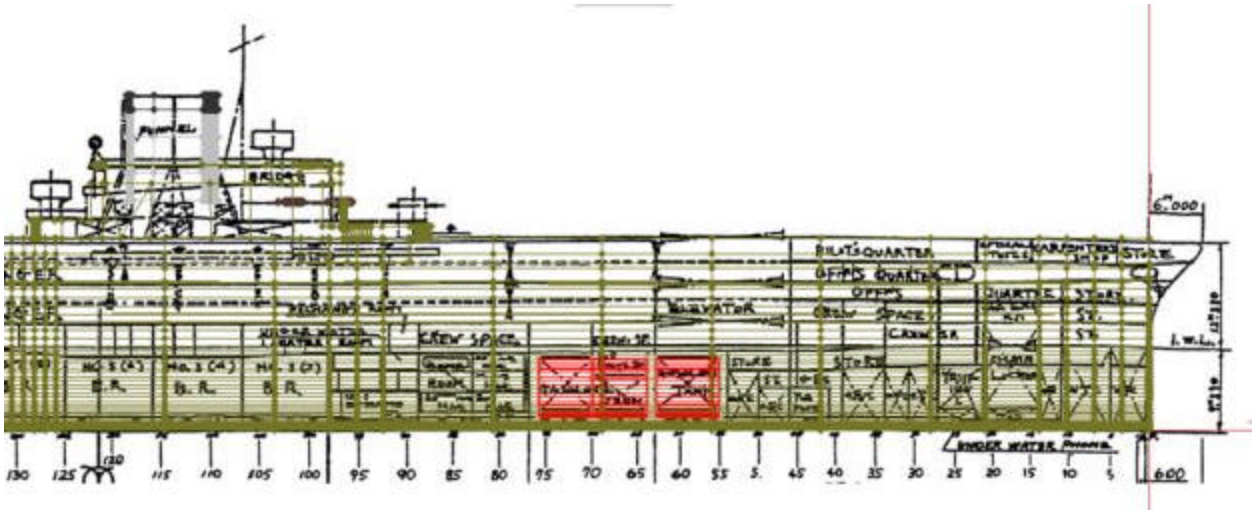
A question arose recently regarding the amount of aviation gasoline (av–gas) carried by various Japanese aircraft carriers. The aviation fuel capacity is not considered as vital a characteristic as the ship's fuel capacity, or the number of guns, or the length of the shi Consequently, there are few sources that report this characteristic. When a figure is given, it is typically as a component of the ships displacement under a particular load (e.g. trial, standard or full load displacement). In an effort to determine the aviation fuel capacity for the carriers *Kaga* and *Hiryu*, measurements were taken from scaled line drawings of these ships. Basic math was applied to calculate the volumes of the av–gas tanks in units such as tons as per other carriers such as *Shôkaku* and *Taihô*, which have documented av–gas capacities. This manual method proved difficult and unreliable.

A second approach was to use these same line drawings to create a 3 dimensional model of the gasoline tanks and to let the modeling software calculate the volume for the tanks. As a test of this method, a 3D model was created of the gas tanks for *Taihô* in order to compare the results from the software against known accurate data for that shi The following images show the 3D mesh for *Taihô's* forward av–gas tanks merged with a partial model of *Taihô* against various scanned art as a backdro



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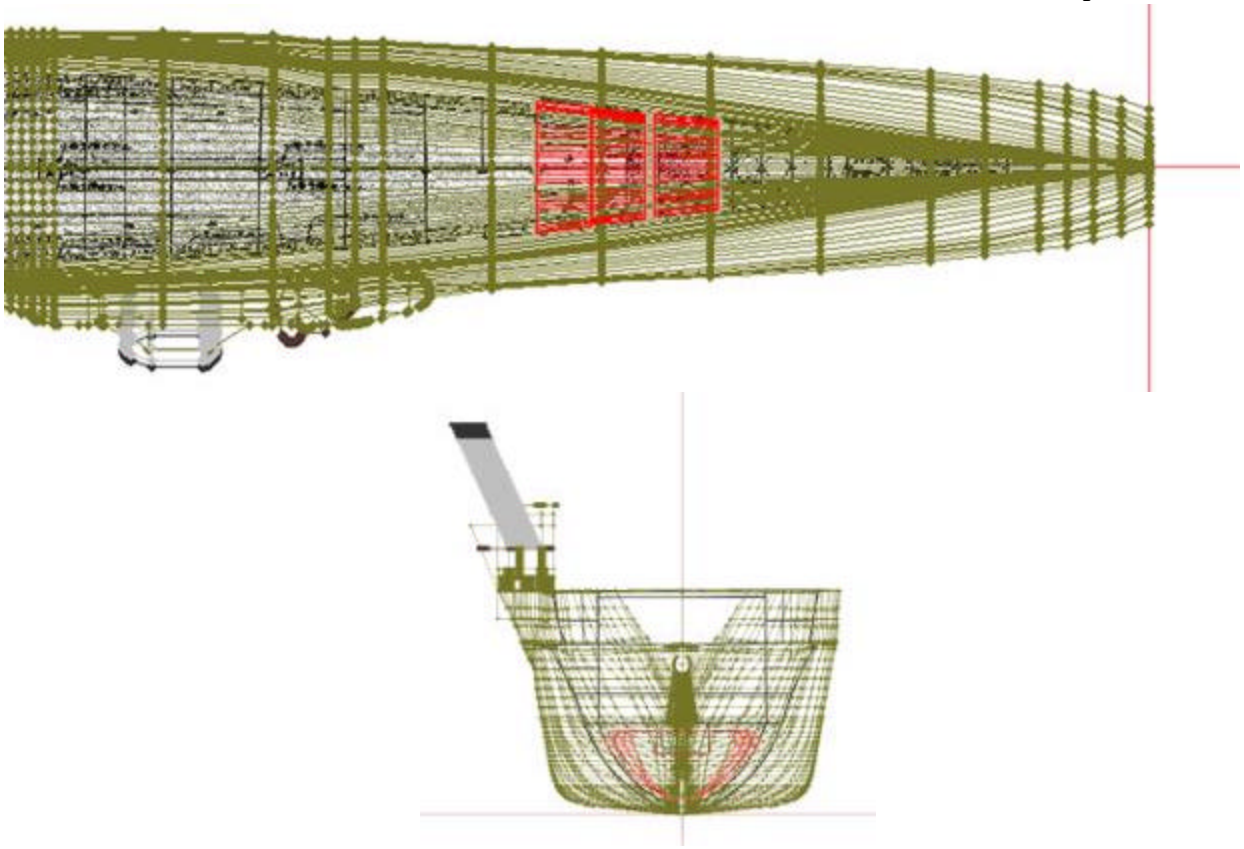

The results from this method were extraordinary with a calculated error of 0.07% versus the known values. This same method was then used to calculate a reasonable estimate of *Hiryu*'s maximum stores of aviation gasoline.

Summary

The topics, ideas and examples that have been presented are a sampling of how the computer and various types of computer software can aid the naval researcher and historian. More samples have been excluded than included. It's difficult to imagine trying to deal with all of the information, all of the data, all of the images, and all of the correspondence without using a computer. I wouldn't know how to do many of the things that I have done without such tools.

[i] College Park, MD, U.S. National Archives and Records Administration, Record Group 38.4.15.

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[ii] Watts, Anthony J., and Brian G. Gordon. *The Imperial Japanese Navy.* Garden City, NY: Doubleday, 1971.

[iii] U.S. Naval Technical Mission to Japan, "Captured Japanese Ships' Plans and Design Data", U.S. National Archives and Records Administration, College Park, MD, Record Group 019, Microfilm M1176, 10 rolls.

[iv] Lawson, Robert, and Barrett Tillman. *Carrier Air War in Original WW II Color*. (Osceola, WI: Motorbooks International, 1996), 141.

[v] Gakken, *Carrier Taihô & Shinano – Pacific War History Series #22. Tokyo, 1999.* (Japanese language publication)

[vi] U.S. Air Force, "Japanese Repatriates, Otake", 1946, U.S. National Archives and Records Administration, College Park, MD, Record Group 342, Motion Picture Film NWDNM–342–USAF–11026.

[vii] Low, Joseph E., "Mechanisms of Imperial Japanese Navy Warships in 3–D. <http://www.ijn.dreamhost.com/>, April 2001.

[viii] U.S. Naval Technical Mission to Japan, "Captured Japanese Ships' Plans and Design Data", U.S. National Archives and Records Administration, College Park, MD, Record Group 019, Microfilm M1176.