# Optimizing the Calculator User Interface: A Little Clutter Can Go a Long Way

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In my previous article, "Keyboard Clutter, Keystroke Counts and Calculator Menus" (in V27N1), an attempt was made to determine some guidelines for assessing the calculator user interface (UI) and to establish mechanisms which lead in the direction toward improvement in ease of use. This time around, let us delve further into some specific scenarios whereby an existing machine keyboard can be improved. First, let's quickly review some HP calculator UI evolution.

## History of the Function Explosion

The HP35 provided a keyboard with virtually no shift keys and a single function per key (save the "arc" key for the 3 trig functions). Keyboard clutter was minimized and average keystroke count was close to 1 per function. Then, functionality was steadily enhanced with the HP45/HP80 models by adding a formal shift key, a second shift with the HP55 & HP25 and culminating with three shifts "f", "g" and "h" with the HP67 and HP34C models. With keyboard clutter at an all-time high, another solution for further increasing the functionality was utilized with the HP41 "Nut" series via spelling function names through the ALPHA keyboard in conjunction with key assignments and USER mode helping to lighten the keystroke-count load. In order to extend further beyond the many functions provided by the Nut series, still a third scheme was adopted starting with the Clamshell 18C and 28C machines and continuing in the Pioneer and Charlie series units; namely the soft-key menus. Now, a single marking on a keyboard could be used to activate multiple sets of up to six key functions at a time in the top row of keys as labelled by the bottom row of the LCD. Thus, by placing menu names on primary and/or shifted key positions, key clutter could be reduced while functionality increased at the same time. (However, average keystroke counts did increase as a result.)

As functionality continued to grow further, the need arose for soft-key menus to have multiple pages of key definitions in some cases and sub menus in others (and sometimes both).

Navigating through multiple menu pages was done using three primary methods:

A. With the 18C, 19B and 17B families, the sixth menu position was labelled "MORE" or "OTHER" which when pressed, moved to the next menu page. Although the last soft key indicated that additional pages existed, the downside with this method was that each page of the menu was reduced by

one position from six to five. This translates to more pages per menu in a few cases and thus higher keystroke counts.

B. With the HP48, 49 and 50 series machines, the menus could hold all six key definitions per page, but keyboard keys labelled “NEXT” and “PREV” were used to traverse through the pages. Thus two additional keyboard positions were tied up by this method, plus no indicator existed to notify the user that additional pages were available. The loss of a physical key (plus a shifted key position) would ultimately mean that two functions were potentially moved to menus, meaning their access required additional keystrokes. Also, the lack of visible cues to additional menu pages could translate to potential erroneous searches for functions which are located in other menus.

C. Finally with the HP42S, multipage menus utilized the full six functions per page, plus they activated an arrow annunciator in the LCD. This was the indicator that more pages were available via the up- and down-arrow navigation keys which were already on the keyboard to perform other functions. As a result, this method represented the most efficient menu navigating scheme from the standpoints of no wasted soft keys, no exclusive keyboard navigating keys and also notification to the user that additional pages existed. (The hp33S and 35S also use this method of lighting up arrow annunciators in their displays to indicate that additional menu functions are available even though they do not use soft keys.)

With respect to menus containing submenus, all the aforementioned models contain some menus with submenus; however the only models which identified that a soft key actually took the user to a lower-level menu was the 49/50 series machines, which drew a short horizontal bar above the softkey label. (This was an outgrowth of the very-clever scheme first utilized by the French team with their Meta Kernel library for the HP48 series. Thanks, Jean-Yves Avenard and company!) All the others simply showed the submenu name with no way to know that it wasn’t simply another individual function. Again, some potentially wasted key presses might have resulted from erroneous searches for functions located elsewhere. It is interesting to note that so far, no HP machine with soft-key menus has taken advantage of the combined best methods for incorporating multipage menus and menus with submenus.

Finally, something should be said regarding the use of a slightly different background colour painted around keyboard function names which activate menus. This practice began in January of 1988 with both the HP28S Clamshell and 27S Pioneer scientifics and continued through 1991 with the remainder of the Pioneer scientifics up to the 32SII, and the HP48S series and to a limited extent with the 1993-98 HP48G series (with only the menus on the shifted positions over the keypad keys, but not with others for some reason). However, the practice stopped there and was abandoned with all the Student machines (starting with the HP38G in 1995 on up to the present-day HP39gs and 40gs) and the later graphing

machines (starting with the hp49g in 1999 up to the present-day hp50g) and scientifics (with the hp33s and 35s). Also, it should be mentioned that this was never utilized on any financial units. I personally find this feature extremely useful and it is sorely missed on the current crop.

## Minimizing "Keystroke Counts" As Top Priority

To me, optimizing the user interface means making the calculator as easy to use as possible – and this has a great deal to do with minimizing the number of keystrokes. Since we do not have an infinite number of keys where each corresponds to a single function, other methods must be used to minimize keystroke counts while maintaining a large function set. In the case of HP's higher-end financial machines, the designers seemed to have overdone the menu scheme while leaving numerous keyboard function positions empty. Since accessing a function via menu has both the negative aspect of extra keystrokes plus the undesired possibility of selecting the wrong menu, there is a real benefit to maximizing the number of functions on the keyboard without providing mind-boggling clutter. A good compromise might be to employ two shift keys like many of the more-recent scientifics such as the HP35S.

If we examine the current HP17BII+, there exist over 245 functions accessible via its 36+ soft-key menus, and requiring an average of over 2.5 keystrokes per menu function.[1] And yet, on the keyboard with its single (underutilized!) shift, one finds that only 17 of the 36 potential shifted key positions have been used. The more-complete use of the shifted key positions would allow exposing additional "buried" functions; thus reducing key presses while also making them easier to locate. Plus if a second shift was added, still another three dozen more keyboard positions would be available. And finally, by employing some of the aforementioned menu-navigation techniques from the other HP machines, functions searching could be improved.

## Adding a Second Shift Key Intelligently

Since the key layout of the Pioneer-series calculators is the same as the HP17BII+, a comparison of their shift-key handling is useful. Of those eleven machines, eight had a single shift. Just above the shift sat separate up- and down-arrow navigation keys in the 17B, 27S, 42S and 17BII while the 22S, 32S and 14B placed both "up" and "down" functions on the same key in the shifted and primary positions,

[1] For the complete keyboard metrics of the HP17BII+ and many more machines, check http://www.pahhc.org/keyoards.htm on the web.

respectively. (The HP10B did not have “up” and “down” navigation capability.) Of the remaining three machines, the HP20S, 21S and 32SII placed their “up” and “down” functions on separate shifted key positions elsewhere on the keyboard. Since there is no need for a radical adjustment of functions already on the 17BII+ keyboard, let us add the second shift key just above the first (in the current position of the “down” key) and change the “up” key to a primary “down” key with “up” as the upper-shifted function. Since the function names corresponding to the original shift are on the key fronts below the primary functions, it would be logical to place the “second-shifted” names above the keys. As a result, the shift markings should probably be updated to indicate which is for those functions above and which for those below, in a similar fashion to the Pioneer calcs. This transformation is shown in Figure 1.


*Figure 1. HP17BII+ navigation and shift keys (left) and a proposed version with a second shift key along with navigation keys combined onto one key (right).*

## Exposing Functions Logically

At this point, all that might have to be done would be to bring a whole host of formerly menu-embedded functions out onto the keyboard. However, a few additional tweaks would simplify the UI even more. As suggested in the previous article:

(1) In a similar fashion to the HP42S, the soft-key menu should be able to be dismissed so the LCD may be optionally used to display two lines of information; and

(2) it would be a much more efficient use of the keys in the top row if they were marked with functions that would be active when the soft-key menu was turned off.

Thus when a menu was active, the top-row keys would correspond to the current soft-key menu functions, and when no menu was present, the keys would take on their "native" functions as labelled. While a second-level or lower-level submenu was active, the EXIT key would transition to the parent menu and when a top-level menu was active, EXIT would dismiss the soft-key menu altogether.

Next, the need for the "MAIN" menu would be eliminated and those functions could be moved to the keyboard in various places, as diagrammed in Figure 2 below. From the original MAIN menu, the SUM, TIME, SOLVE and CURRX menus would be placed directly on keys in the top two rows. All remaining original plus new menu identifiers would be highlighted with frames drawn around them to aid the user. The FIN menu would no longer be necessary, as four out of five its subordinate menus would also be located directly on keys. The upper-shifted key plane would then be dedicated to the newly-relocated financial and business-related functions. The BUS menu would also be eliminated as the individual functions from its four sub-submenus (%CHG, %TOTL, MU%C and MU%P) would become functions on this key plane. The same would be the case for the components of two sub-submenus "PER" and "CONT" of the ICNV submenu of "FIN". Since both the MU%C and MU%P menus originally contained functions for COST and PRICE (and also since they share the same financial storage registers for these items), it made sense to have only one common set of these two functions on the keyboard. Next, the functions under the "CALC" submenu of TIME would be moved to this key plane as well. The idea here would be to group together the functions which were together in a menu previously, and to connect their names with lines in a similar fashion as smartly done on the shifted keyboard of the HP14B.

With more space available on the lower-shifted key plane, additional key positions there could accommodate some of the non-business-related functionality. The MATH, DSP and MODES menu key positions would be eliminated from the second row. On the shifted numeric keypad would go the functions in the MATH menu along with those of the DSP menu (with the decimal-point and comma delimiters combined on a single key position as a toggle). On the lower-shifted positions up on the second row would be all but one of the functions of the MODES menu, with the printer functions grouped around the position of the original PRINTER menu. The final position of the MODES menu, the INTL submenu, would be on a lower-shifted position in the top row.

In the LCD, the two changes previously suggested would be implemented, namely: (1) Having the "arrows" annunciator come on when the currently active menu is multi-page in conjunction with the arrow keys being enabled to navigate between menu pages. This would permit a maximum of six soft keys per menu page and would eliminate the need for the wasteful "OTHER" or "MORE" soft key.

(2) Adding short bars above soft-key menu function identifiers which activate submenus. An overall picture of the newly designed “HP17BII++” is shown in Figure 3 along with its predecessor.

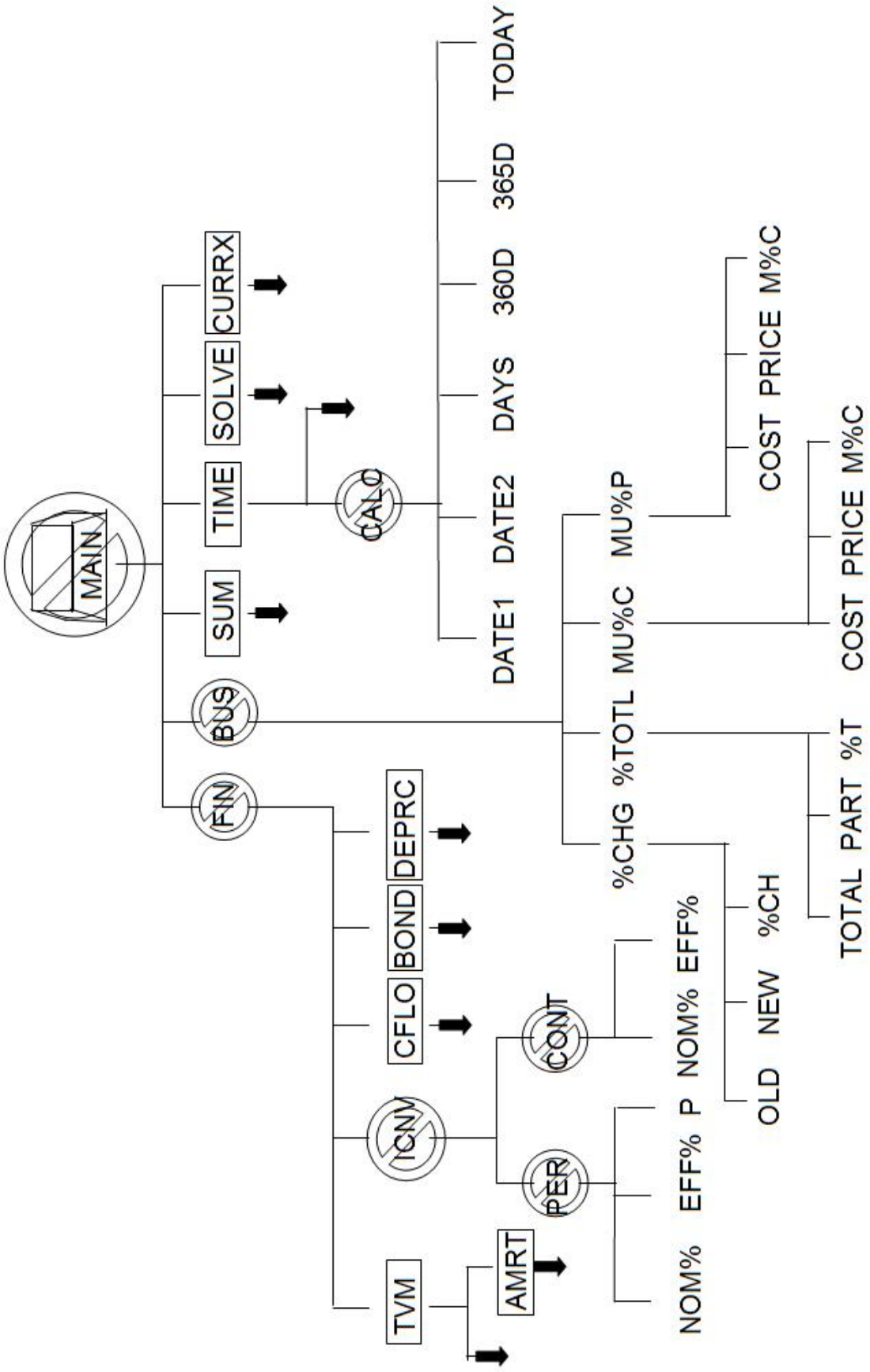


*Figure 2. Original HP17BII+ Main Menu and subordinate menu map showing proposed updates. An item with a strikethrough would be removed, a boxed item would become a menu-activating key and the others would become functions placed on the shifted keyboard.*


*Figure 3. The current HP17BII+ and the newly-proposed "HP17BII++" containing display, menu and keyboard updates to improve ease of use by both reducing keystrokes and providing additional information on the keyboard and in the LCD. Key labels with frames drawn around them represent functions which activate menus in order to distinguish them from labels which simply execute individual functions.*

## Slightly Simplifying ALPHA Entry

Currently, the two-key ALPHA entry method starts with the top-level menu as shown at the top of Figure 4. Since the letter choices are spread over the entire six keys, access to the 35 various symbols would require first pressing any key at the top level, followed by the "OTHER" key on any of the six submenus. This reveals the first page of a seven page sub-submenu, each with a "MORE" key in the last position. Thus, to access the dollar-sign ("$"), one would first press a top-level key, the "OTHER" key, the "MORE" key and then the "$" key, since it is on page two of the sub-submenu. In the revised machine, with the availability of a full six soft keys per menu, ALPHA entry may be simplified somewhat. The alternate scheme proposed (as shown at the bottom of Figure 4) has the letters distributed over the

first five (rather than six) keys of the top-level menu with the sixth position for direct access to the multipage submenu of symbols. Thus to access the "$", it would simply be [SYMBL] [ $ ], saving two keystrokes. Since the Symbol menu pages would not require "MORE" keys, the 35 symbols require only six pages rather than seven.

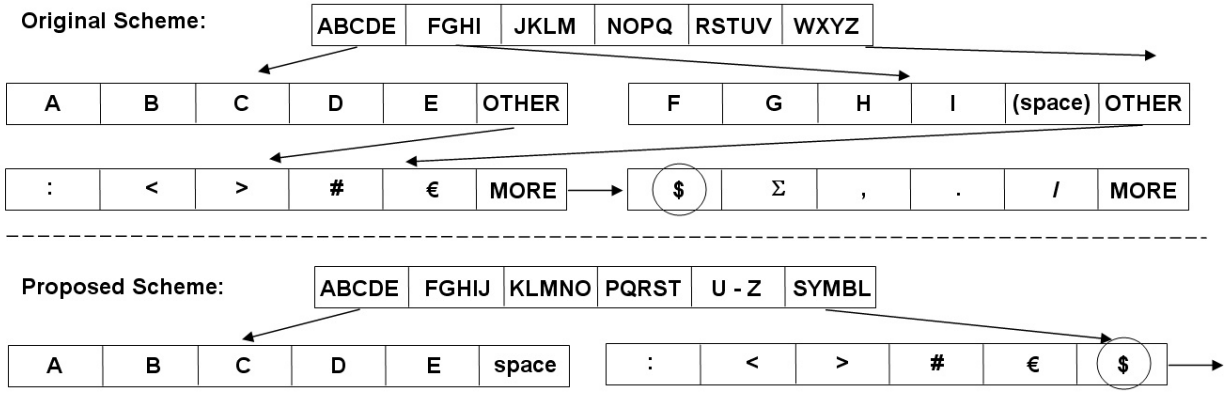


*Figure 4. The original ALPHA-entry scheme (top) and the proposed scheme (bottom). Due to the elimination of the need for "OTHER" keys, the letters span only five soft keys instead of six, allowing the Symbols multipage menu to be accessible one level higher.*

## Analyzing the Results

Following all these changes, a tally of the calculator keyboard metrics was conducted on both the original and improved machines, with the results shown in Table 1 below. One of the most significant changes was the increase in the number of shifted functions from 33 to 68 while reducing the menu function count from 245 to 196. As expected, keyboard clutter increased from 1.324 to 2.486 or a little over one function per keyboard key. (The overall function count dropped slightly from 355 to 352 due to combining three functions with others which originally were on separate keys. An example of this would be converting the two menu function positions for the comma and period radix-mark choices into a single key which would toggle between the choices.) While the number of functions remained virtually the same, the total number of keystrokes required was reduced by 11 percent from 867 to 771, reducing the average keystroke count per function from 2.442 to 2.190. In the menus, the overall keystroke count dropped a whopping 35% from 614 to 399. It is a big improvement to permit navigation to functions in the menu tree to be reduced by more than a third. With more function names physically visible to the user, transferring a large chunk of the navigation chores from the fingers to the eyes greatly improves ease of use. And while the keyboard looks somewhat busier, it is not so cluttered as to bewilder an average user.

| Category | HP17BII+ | proposed HP17BII++ |
|---|---|---|
| # menus | 36 | 26 |
| | | |
| # menu functions | 245 | 196 |
| | | |
| # primary keys | 34 | 33 |
| | | |
| tot # primary functions | 27 | 26 |
| | | |
| tot # shift keys | 3 | 4 |
| | | |
| tot # 2-key shifted functions | 33 | 68 |
| | | |
| tot # 3-key sequences | 40 | 40 |
| | | |
| tot # 4-key sequences | 10 | 20 |
| | | |
| tot # 5-key sequences | 0 | 2 |
| | | |
| # menu functions | 245 | 196 |
| | | |
| tot # Menu keystrokes | 614 | 399 |
| | | |
| tot # functions | 355 | 352 |
| | | |
| Keyboard Clutter (# fcns per key) | 1.324 | 2.486 |
| | | |
| Keystroke Count | 867 | 771 |
| | | |
| Keystroke count per function | 2.442 | 2.190 |

*Table 1. The metrics tally for the HP17BII+ versus the proposed "HP17BII++". With the addition of another shifted key plane and the resulting ability to eliminate ten soft-key menus, clutter goes up but keystroke counts drop significantly. For the detailed analysis, consult http://www.pahhc.org/keyboards.htm on the web.*

## Summing Up

First, to summarize, our proposed calculator incorporates the following features:

- Addition of a second shift key and shifted key plane above the physical keys
- Organizing the functions with financial/business on the upper shifted key plane and math, modes and other items on the lower key plane
- Labelling the top row of keys with primary and shifted functions in conjunction with allowing the soft-key menu to be optionally dismissed

- Elimination of the “MAIN” menu with its submenu functions moved to the keyboard for direct access. Adding highlighting borders around all keyboard markings which activate menus.
- Removal of ten soft-key menus and submenus with their functions moved out onto the keyboard. Positioning of related function keys from the same menu in proximity to each other, with keyboard markings showing their relationship.
- Elimination of “OTHER” or “MORE” in the sixth position of multipage menus by enabling page-to-page menu navigation via the up and down arrow keys. In conjunction with this, activation of the “arrows” display annunciator whenever the currently-active menu contains multiple pages.
- “Marking” with a bar over top the displayed names of soft keys which point to submenus
- Taking advantage of full six-key menus by reducing the ALPHA multipage and multi-level menu tree to fewer pages and fewer levels

In closing, it is believed that all of the changes proposed here would be possible without modifying any of the physical hardware of the calculator; only firmware and key and keyboard markings would be required. Virtually all of these changes are based on features which appeared in earlier HP machines in one form or another. To me, this confirms the need for a development team to consider the retention of past successes to be as valuable as rectifying failures or creating something new from scratch.