Flight Inspection Situation Awareness

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ABSTRACT

Many of today's modern flight inspection systems have available extensive computer power and advanced graphics presentation possibilities. How can this be used to help give the flight inspector a better and quicker understanding of the situation he/she is investigating?

This paper and accompanying presentation focus on ergonometric issues from the operator side, and discuss the important balance between the overwhelming amount of information available versus giving the operator a clear understanding of the situation.

Better ways of giving the presentations in graphical, intuitive formats, such as three-dimensional signal-in-space models, may provide the operator with more information at a glance. Real-time moving map overlay is another such example. Several examples and new ideas are discussed and presented.

BACKGROUND

The software of a flight inspection system basically has three main tasks to accomplish:

1. Data collection and control:

The software must make sure the different navigational sensors in the system are controlled, and that data from the sensors are collected in real-time.

2. Calculations and algorithms:

The software needs to perform all relevant calculations and algorithms related to flight inspection, based on the collected sensor data, as well as on facility data and specific flight inspection parameters.

3. Operator interface:

The software is also responsible for presenting real-time information to the operator, such as:

a. System status
b. Real-time signal values
c. Calculations
d. Facility information

Of course, the operator interface must allow the operator to execute the necessary control of the system, such as selection of flight inspection procedures, facilities and position reference system to use.

Previously, it was common to solve all these three software responsibilities in one computer. The computer, typically real-time operating system based, would normally be advanced and powerful enough to provide real-time data collection and calculations. In addition, simple numerical- and curve-presentations would be available, but advanced real-time graphical presentations were out of reach.

Today, the technology available opens for graphical presentations of a completely different quality than previous. Large amounts of on-board memory, dedicated graphical

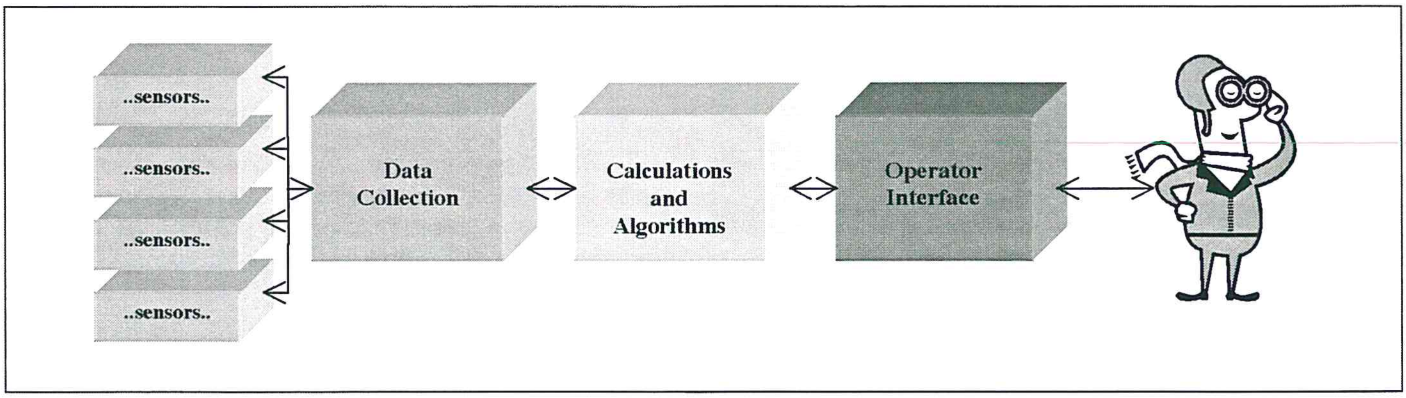

Figure 1: Typical software responsibilities

processors and ever increasing CPU-speeds all contribute to this. Even more important is the advent of large flat-screen displays providing excellent hi-quality graphical presentations.

In addition, modern software development tools allow the use of ready-to-run components to be included in the software. This greatly reduces the development effort needed to include even advanced graphical components into your flight inspection system.

GRAPHICAL PRESENTATION

The first thing to consider when designing a modern graphical interface, is how to present the necessary information to the user in the most efficient way.

The amount of information available to the operator of a flight inspection system is overwhelming. From a simple system consisting of a GPS-based positioning system and a localizer-receiver, we could easily provide the user with close to 100 parameters updated 10 times pr second. It is obvious that the flight inspection operator will not be able to digest all these parameters, nor are all of them relevant at all times.

Operator Attention

The aim must be to give the user the information needed and desired, providing attention to the parameters important for the ongoing inspection procedure. In addition, the software should use visual and audible methods of getting the operators attention when necessary.

A practical result of this, as seen in the Norwegian Special Mission UNIFIS 3000 software, is the use of colors and audio signals to get the operators attention. When any parameter change appears more rapidly than a predefined rate, or when the parameter value reaches a value outside a predefined range, the operator will be alerted.

Figure 2: Example of Norwegian Special Mission's UNIFIS 3000 monitor alarm. Not clearly visible in gray-scale, the real-world system utilizes bright colors to attract attention

In the example seen in Figure 2, several monitor areas are displayed, each covering different logical aspects of the overall flight inspection system. When a potential problem or situation occurs, such as a lost link to the DGPS ground reference station, this is indicated by a flashing red light and audio warning. Text in the message section provides quick information. To get more detailed information, the user may simply click the active warning button. A window containing such information will then appear.

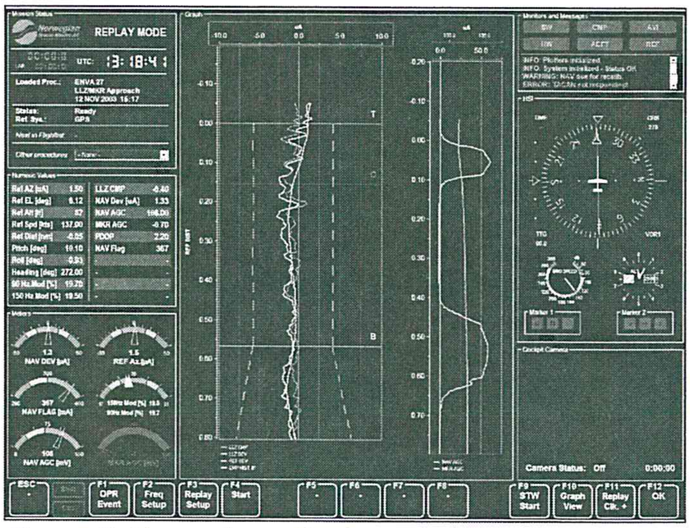

Figure 3: Example vertical graph from Norwegian Special Mission UNIFIS 3000 software

This example shows how the operators attention may be drawn towards any arising situation which may have consequences for the flight inspection operation in progress. Conversely, if no special operator attention is required, the relevant sections of the display is fading into a low-contrast mode, allowing the operator's focus to be elsewhere.

Graph components

The single most information-providing component of a graphical display, may arguably be the graph component. It provides a view of both current and previous sensor data at a glance, and gives the operator immediate information about trends and drifts. Related to approach procedures, flight inspection system historically have had a tendency to present the data in a horizontal left-to-right plot. Figure 3 shows a graph component displayed vertically. This gives a far more intuitive presentation to the operator.

Displaying historical data is another function that is very useful in a graph component. The operator may view the results from one or more previous runs performed months or years ago, and compare these data with the current real-time data as the flight inspection procedure is progressing.

Real-time calculation of tolerances is also possible. The tolerances may be displayed directly on the graph, giving the operator immediate awareness of the facility performance related to these tolerances.

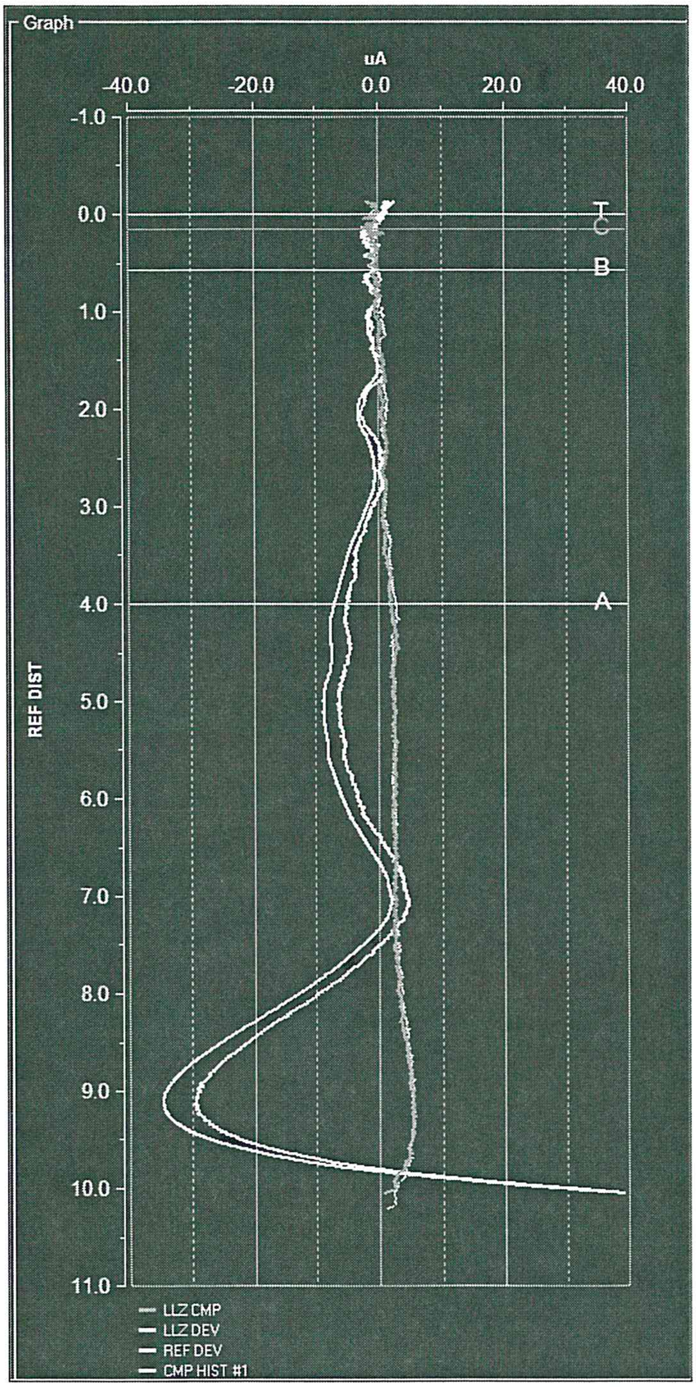

Figure 4: Zoom-out for full approach overview

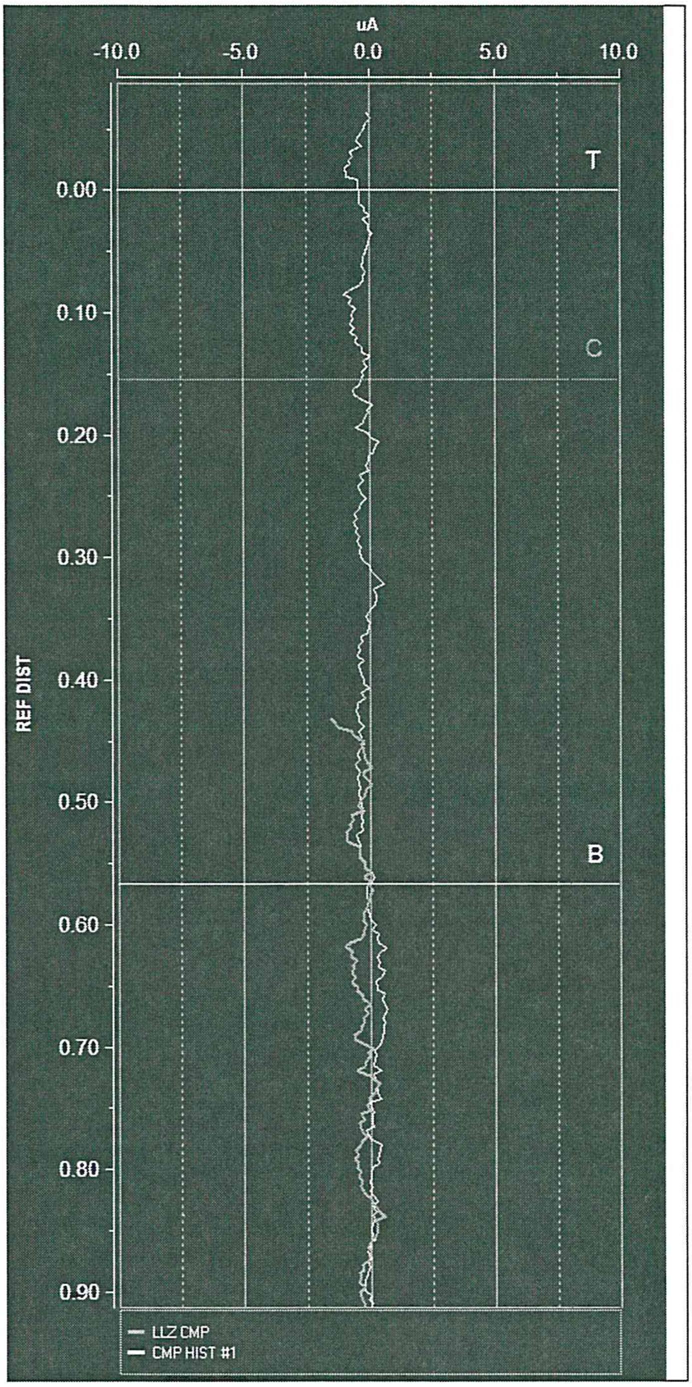

Figure 5: Compare real-time data with full historic data plot

The graph component may of course be scaled and scrolled in both x- and y-directions, and any parameter may be selected for display. Figure 4 shows an example of a zoom-factor allowing a full localizer approach run to be displayed in one view.

More advanced features involves using the Windows-familiar “drag-and-drop” functionality to place a certain parameter onto the graph component. This could be extremely useful if the operator becomes aware of a parameter not currently plotted in the graph component which reaches unusual values. The operator may then click the parameter, drag it onto the graph component, and drop it. The history of that parameter for the full duration of the ongoing run is plotted. This allows extreme rapid situation investigation by the operator.

For specific procedures, such as VOR/TCN orbits or radials, a circular plot may provide additional information. This type of plot may show the deviation of the measured radial around the VOR station. In certain situations, a VOR station may have repeatable characteristics offset by 180 degrees, normally caused by internal VOR problems. Such situations are far more easy to see for the operator in a circular plot.

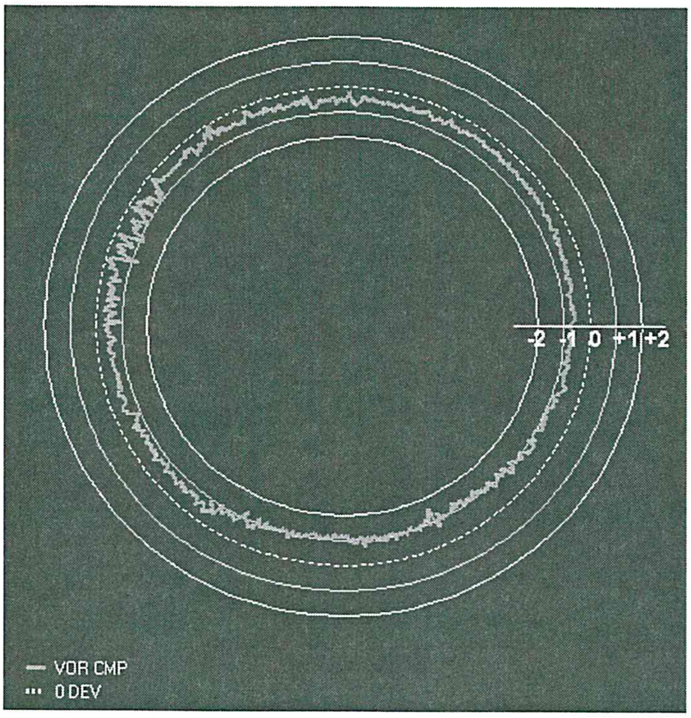

Figure 6: Circular VOR orbit plot

For approach procedures comprising both localizer and glide path investigations, three-dimensional views may be generated. Such views can show the theoretical zero-DDM-line based on facility information, and simultaneously display the measured in-space zero-DDM signal. Full three-dimensional movement and view selection makes this a very powerful visualization tool.

Other graphical components
In addition to curves, several other graphical components may prove useful for the operator.

Gauges are often used to give an analog-style presentation of current parameter value. By using color-coding of the scales on the gauges, the operator is immediately aware of the parameter value compared to its predefined range.

The use of faded-out colors for gauges displaying non-active parameters further enhances the operator focus on the active gauges.

Besides the actual operator awareness of flight inspection related issues, the awareness of the aircraft orientation and position if also of interest. A *Moving map* presented for the operator is very useful for quick orientation of the aircraft position related to the navaids under inspection. Enhanced moving map functionality allows clear identification of waypoints and estimated flight paths to be flown for the selected flight inspection procedure. This is especially useful for crossovers, RNAV-procedures, radials etc.

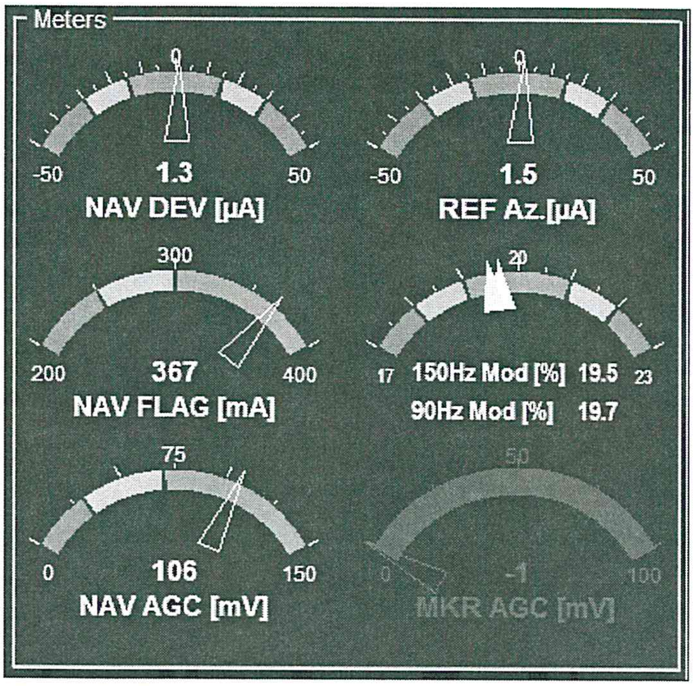

Figure 7: Gauges giving immediate parameter indication. (Color coding not clearly visible in this print

Standard cockpit instruments, like compass rose, horizontal situation indicator etc, are also of value to the operator. Modern systems fully integrates such instruments into the graphic display, further improving the operator's understanding of the situation.

Facility overview
An overview of the facility under inspection could be very simple. If an en-route VOR is the only facility being inspected, a detailed facility map is not required.

But with modern flight inspection equipment, the situation awareness related to the selected facility may become more important. Firstly, the inspection may cover several navaids simultaneously, creating a more challenging situation. Further, the increasing focus on RNAV, GPS-based procedures and other more complex inspection scenarios further suggest the necessity of providing the flight inspection operator with graphical facility information.

The screenshot seen in Figure 9 shows an example facility database from the Norwegian Special Mission UNIFIS 3000 software. In addition to the actual parametric information, a map of the facility with markings of all navaids is displayed for the operator. This greatly enhanced the operator's situation awareness related to the task at hand.

The example shows a specific runway with markings for threshold, runway end, LLZ, GP/DME and DVOR/DME.

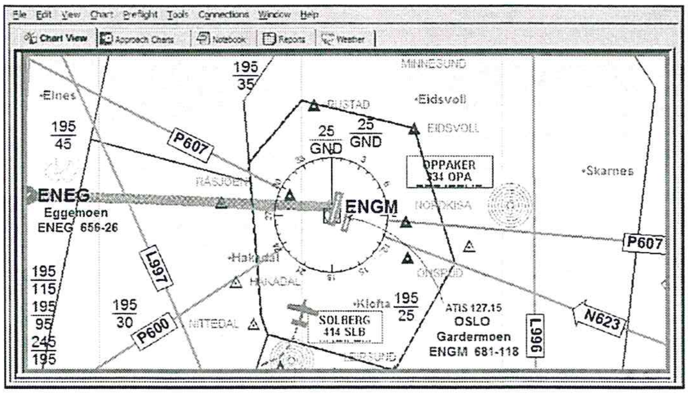

Figure 8: Moving map provides immediate aircraft position awareness

Figure 9: Facility with graphical situation information

CONCLUSION

This paper has presented some methods and ideas for improving the quality of the data presentation for the flight inspection operator.

It will be interesting to follow the development in this field in the years to come, a development which will greatly benefit the flight inspection community.