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FEASIBILITY STUDY ON THE CAPABILITY FOR VISUALLY AUDITING BUOY --ETC(U)
JUL 78 F S BAUMAN, B J WAELBROCK, F GIOVANE

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REPORT NO. CG-D-45-78

# FEASIBILITY STUDY ON THE CAPABILITY FOR VISUALLY AUDITING BUOY POSITIONS USING VTS RADAR AND/OR LOW LIGHT LEVEL TELEVISION

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July 1978

Final Report

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## NOTICE



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An investigation was made into the feasibility of incorporating visual auditing of buoys into the Vessel Traffic Services program without significantly affecting available resources.

Buoy position audit using low-light-level television does not appear feasible as only general aid condition information is currently available. LLLTV does not produce adequate position information.

Buoy position visual auditing using VTS radar could be feasible if certain improvements are made in the information display and interpretation areas.

Coast Guard VTS units do not presently have the resources to conduct an aggressive, accurate visual buoy position audit program.

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# METRIC CONVERSION FACTORS

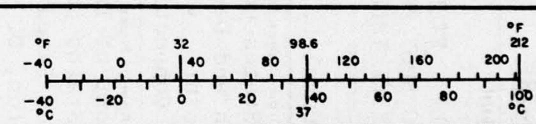
## Approximate Conversions to Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | *2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 6.5 | square centimeters | $cm^2$ |
| $ft^2$ | square feet | 0.09 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.8 | square meters | $m^2$ |
| $mi^2$ | square miles | 2.6 | square kilometers | $km^2$ |
| | acres | 0.4 | hectares | ha |
| | | **MASS (weight)** | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| | | **VOLUME** | | |
| tsp | teaspoons | 5 | milliliters | ml |
| Tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| $ft^3$ | cubic feet | 0.03 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.76 | cubic meters | $m^3$ |
| | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.


## Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| | | **AREA** | | |
| $cm^2$ | square centimeters | 0.16 | square inches | $in^2$ |
| $m^2$ | square meters | 1.2 | square yards | $yd^2$ |
| $km^2$ | square kilometers | 0.4 | square miles | $mi^2$ |
| ha | hectares (10,000 $m^2$) | 2.5 | acres | |
| | | **MASS (weight)** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| | | **VOLUME** | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| $m^3$ | cubic meters | 35 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.3 | cubic yards | $yd^3$ |
| | | **TEMPERATURE (exact)** | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |



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## 1.0 INTRODUCTION

The objective of the study covered by this report is a preliminary assessment of the feasibility of conducting audits of aids to navigation, visually, using Vessel Traffic Services (VTS) radar and/or closed-circuit low-light level television (LLLTV). The study was conducted with limitations on available time and manpower and was intended to cover the general capabilities, limitations, and suitability of conducting audits visually on VTS radar and/or LLLTV only. Development of detailed procedures, detailed workload analyses, and the potential of automated auditing using computer-assisted tracking hardware are not included in this study. The latter of these is planned as a separate effort. The VTS observed to make this study was Houston, as Houston has a computer, radar, and LLLTV. The Houston ship channel also presents a variety of aids, complex traffic patterns and a high frequency of transits which make it typical of VTS ports. Further, the high transit frequency and complex traffic patterns were used to appreciate the normal workload of the Vessel Traffic Center (VTC) personnel.

The approach followed in this study was to first interview personnel who had experience or expertise with the VTS procedures or the equipment used within the VTS program. A review was made of trip reports, local charts, photos, and a motion picture depicting the Houston LLLTV capabilities. Houston VTS was then visited for first-hand observations of the watch procedure, LLLTV, and radar. The LLLTV was studied under different light conditions, and trial audits using this system were performed. Trial audits were also performed with the radar.

Generally, we concluded that although the LLLTV is a useful tool in the visual VTS operation, it has very limited capabilities for auditing buoys without additional and substantial equipment modification. (The detailed conclusions for LLLTV are given in Section 3.2.) It could offer assistance to the aids to navigation program by providing rough checks for aid stationkeeping and characteristics, and also by helping to verify "off-station" or outage reports. Various candidate methods were developed during these visits for auditing using LLLTV.

The radar also has capabilities for assisting with the Aids to Navigation aids to navigation program, but not as a precise auditing tool in its present state. Radar readings were taken to determine accuracy, identifiability of aids, and the time required to perform these readings. It was found that the range and azimuth error of the radar along with the PPI (Plan Position Indicator) display limitations and operator interpretation could not define an aid in less than about 7,000 $ft^2$ of area on the two-mile scale, which would not appear to be satisfactory for a precise audit. (See Table 1 for details.) Most aids could be readily identified up to 6 miles and many others up to and beyond 8 miles. The typical time to take a reading was 20 to 30 seconds. The main benefit of the radar as an auditing tool is that it presently has the capability of being programmed with various (up to 5) "maps." (These maps are electronically retained systems of reference lines; see further discussion in the text of this report.) If one of these maps were programmed with the aid locations, the radar could be used for a quick station check with virtually no additional manhour expenditure (the detailed conclusions for RADAR are given in Section 3.3).

The text of this report gives specifics as to candidate methods and procedures for visual auditing but the general conclusions with regard to auditing are as follows:

1. The electronic tools currently available in the VTS program are probably not precise enough for an exact audit of aids.

2. The present watch section (available manpower) could not readily support the additional time load which would be required if a formal auditing procedure were instituted.

3. It appears that the only way the VTS facilities could effectively be used for auditing would be to eliminate the PPI display limitations and operator interpretation errors. This could be accomplished by interfacing the computer to the radar and generating a synthetic display with the assigned positions of the aids programmed into that display.

## 2.0 BACKGROUND

Briefly, the Houston VTS has radar coverage from a tower on Fort Point, north of Galveston, next to the Houston Ship Channel and Galveston Channel. Pilots are picked up at the sea buoy which is the initial communications check-in point for inbound vessels. ICW (Intra-Coastal Waterway) and other vessels check into the VTS as they enter the channel and also at 16 checkpoints along the channel. The course and speed of the vessels in the system are entered into the VTS computer for tracking. These DRT's (Dead-Reckoning Track) are updated by reports from the checkpoints and monitored by radar and LLLTV where that type of coverage is available. Radar coverage extends for a maximum of 16 miles inland from Fort Point. Shortly after radar coverage is lost, around Red Fish Bar, LLLTV coverage begins. There are four camera locations: Morgans Point, Mitchell Point, Lynchburg, and Tucker Bay. There are some gaps in the LLLTV coverage and it actually stops about 11 miles short of the final turning basin. Voice communications are the only constant factor in tracking the vessels and the computer uses this information to keep continuous tracks on all the vessels in the system. Figure 1 shows the channel, types and limits of coverages, and approximate VTS sector divisions.

## HOUSTON–GALVESTON VESSEL TRAFFIC SERVICE AREA

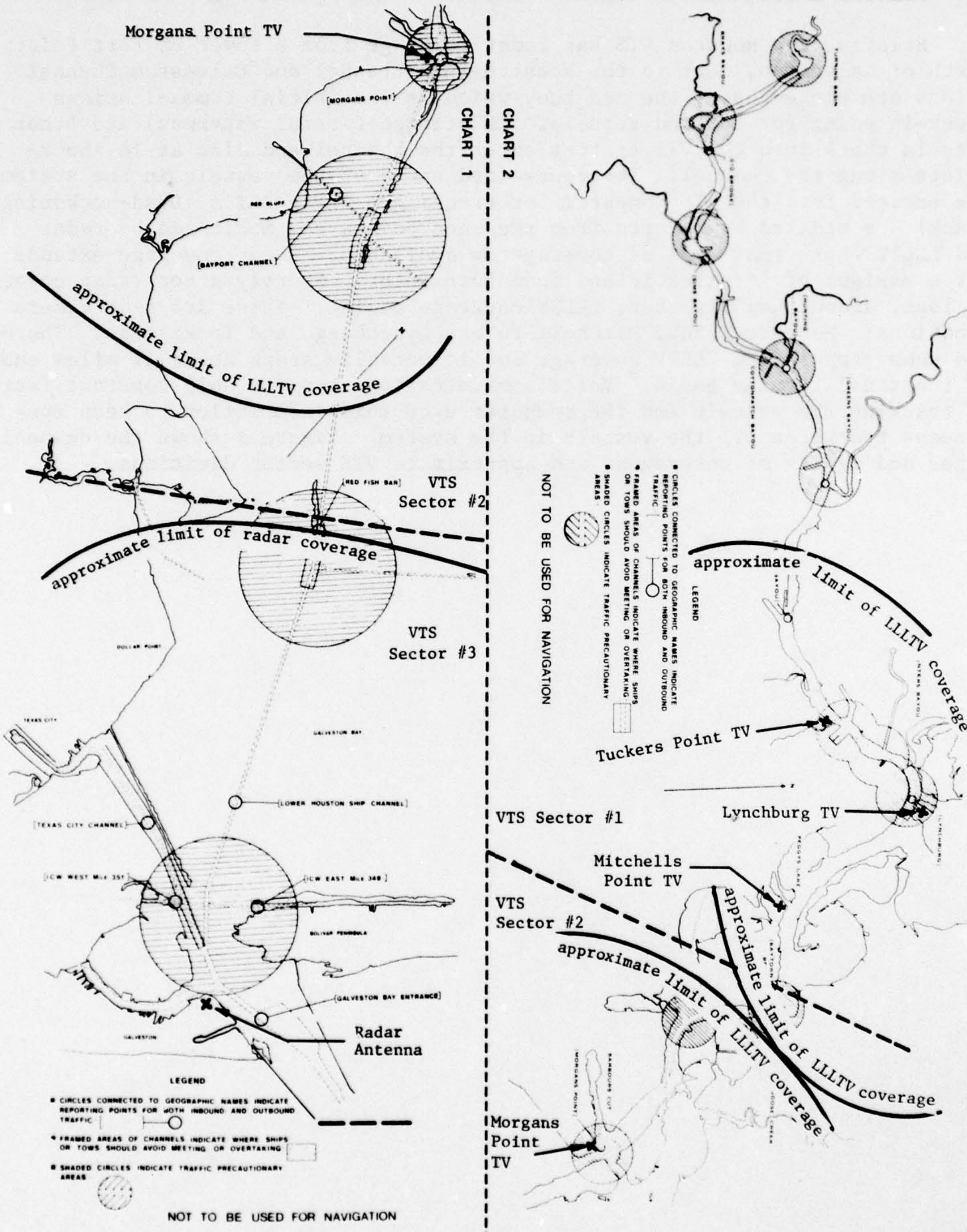


FIGURE 1

HOUSTON-GALVESTON VESSEL TRAFFIC SERVICE AREA

## 3.0 PROCEDURES

### 3.1 General

R&D Center investigators visited Houston VTC the 19th, 20th, and 21st of July 1977 to view the overall VTC watch procedure and the actual operation of the LLLTV and radar. The LLLTV was viewed in different and changing light conditions (e.g., daylight, twilight, moonless night). The LLLTV appeared capable of observing the waterway under all light conditions; however, at night, bright or lighted objects tended to become exaggerated or "bloom." This bloom could tend to obscure nearby objects (e.g., lighted aids to navigation).

### 3.2 Possibilities of Using LLLTV for Auditing Aids to Navigation

The Houston VTS LLLTV was studied to determine its capabilities to perform visual auditing of aids to navigation. The following general observations and concerns are apparent with the LLLTV system:

Variables

1. Zoom lens positioning changes apparent distance and size.
2. Vertical positioning of camera has no remote index/reference points.
3. Horizontal positioning of camera has no remote index/ reference points.
4. Day, night, and low visibility viewing conditions.
5. Operator agility.

Controllable Variables

1. Camera used - specific location and upper/lower viewing positions.
2. Fixed aids, ranges and background for visual referencing.
3. Operator knowledge of aid characteristic, type, and location.

Obvious Advantages

1. Quick check if aids present or not.
2. Night check on light characteristic.
3. Overall picture of traffic and aids.

Obvious Disadvantages

1. No quantitative indexing possible of cameras in the VTS.
2. Limited, if any, range-finding capabilities.
3. Rough articulation of cameras.
4. Visibility variables.
5. Night "bloom" (exaggerated glare from lighted objected) could obscure aids or their reference points.
6. Less than total coverage of channel and sectors.

The feasibility of using VTS LLLTV for visual auditing was tested. Initially a transparent overlay method was tested. This method utilizes a transparency which identifies and illustrates the aid to be audited (in this case, the transparency indicated the position of the aid at a particular time which may or may not be its assigned charted position), as well as various fixed reference points in proximity of the aid. In principle, the transparency is positioned on an LLLTV monitor and the TV picture adjusted to conform to the fixed reference objects. A determination of the position of the aid is made by visually inspecting the actual TV position of the aid with the location illustrated on the transparency.

In order to construct the transparency for testing, 35mm photographs were taken of the LLLTV picture of all visible aids in the Houston Ship Channel. These were processed into 2-1/4 inch slides. Two typical aids, H.S.C. Light #142 and H.S.C. Lighted Buoy #137, were selected (these are pictured in Figures 2 and 3, respectively), and a transparency was constructed to the monitor's scale by marking the aid and at least two reference points on a transparent acetate film. These overlay transparencies were then used on the 19-inch monitor of the VTC, and with the cooperation of the watch personnel, adjustment of the LLLTV was attempted so that the reference objects aligned with their outlines on the transparency.

It took three to five minutes to locate the aid with the TV camera and align the references index. Difficulty was experienced with exact camera alignment due to the jerky camera motion in the horizontal and vertical planes. An exact alignment was never achieved. The zoom variable was eliminated by having shot the reference slides with either no zoom or full zoom.

These overlay alignment trials indicated that another alignment method would be preferable. This preferred method would entail roughly positioning the aid on the monitor with the camera and then manipulate the overlay to final alignment of the index points. To expedite the initial rough camera alignment, quick reference roller index could be prepared to the scale of the 9-inch console monitors which would consist of photographs of all visible aids and their reference points. With this quick reference photographic index, the operator at the console could quickly locate the standard view of the aid and simulate that view on his console-mounted 9-inch monitor by moving the camera. When the standard view is approximated, the overlay could then be attached to and manually aligned on the 19-inch monitor for more exact positioning. These overlays should be insertable to a frame and carrier arrangement on the face of the 19-inch monitor and be moveable in two orthogonal directions. (See Appendix B for suggested prototype.)

The time requirement to fix and index the overlays is, however, substantial, even if properly indexed. Since there is still no quantitative range check, the roller index of standard view index could be used alone for a quick check for certain conditions, such as: (1) is the aid present or missing; (2) does the aid appear to be in a reasonable proper spatial (angular) relationship with its background or reference points; (3) (at night) is its light operating properly.

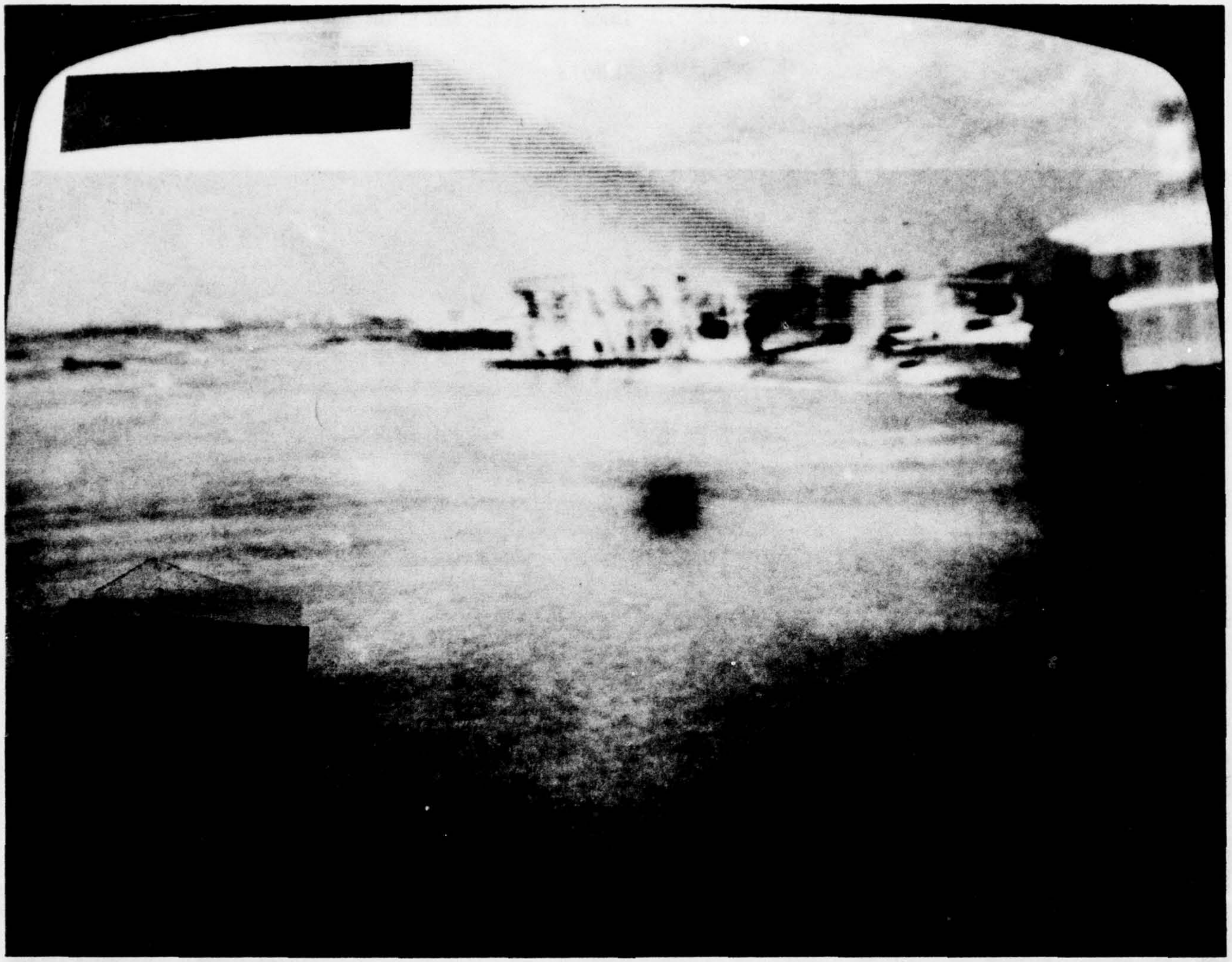

FIGURE 2

HOUSTON SHIP CHANNEL LIGHT 142

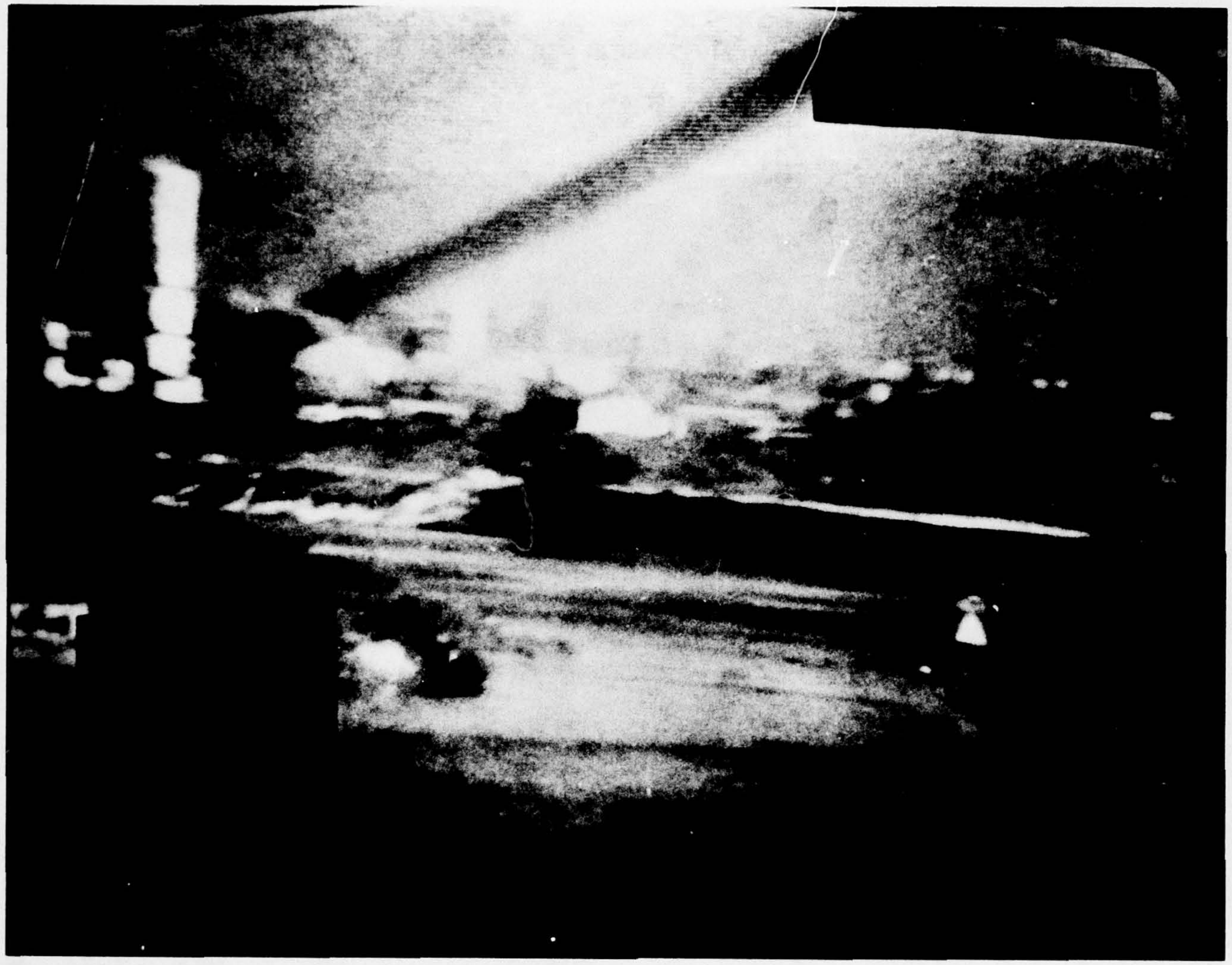

FIGURE 3

HOUSTON SHIP CHANNEL LIGHTED BUOY 137

All three of these items could be judged by the experienced operator without actually positioning the transparent overlay, since he has a scaled visual reference to compare against his monitor. If irregularities are noted by this visual comparison, then the overlay could be used to verify this condition.

As a result of these test, the following candidate methods of auditing aids to navigation were identified:

1. Transparent Overlay Method

   a. Requires catalog of overlays for all visible aids indexed with fixed background reference points.

   b. Requires a frame and carrier for the overlays to be used with the 19-inch monitor. (See Figure 4 for suggested prototype).

   c. Requires scale standard photographic views, made from LLLTV monitor, with reference background catalogued in a quick reference roll type of index at the operator's console.

2. Visual Comparative Method

   a. Requires quick reference standard views as in 1-c above.

   b. Requires operator's judgment to compare the standard view to the actual camera view on the monitor.

   c. Can be used as a first step to the "overlay method" for rough alignment of camera.

3. Subjective Operator Overview Method

   a. Operator requires local knowledge of aids.

   b. Requires recognition of aids in their proper relative locations.

   c. Should not be considered an actual auditing method.

In assessing the benefits of any of these auditing methods, the manhour requirement should be considered with regard to the net result. In Houston the overlay method for auditing every visible aid does not seem to justify the required input of manhours.

For example, it could take three to five minutes to audit an aid with an overlay. There are 19 floating aids and 14 fixed aids in view on the channel. To audit all of these with overlays could required between 1.5 to 2.75 hours or 35 percent of one man's eight-hour watch. However, since the fixed aids will either be there or not, they should not require a full overlay check but a mere visual comparison to the standard view in the roller-index photographic file. Therefore, these checks could be cut down to one or two minutes per aid or 14 to 28 minutes per watch without sacrificing any quantitative information. That same "go no-go" check could be made on the floating aids but would require more operator judgment. Provided this judgment could be developed in the operators, only the suspect aids would have to be verified by the overlay. If all aids appear normal (no overlay checks required), then the audit could take about 0.5 to 1.0 hours per watch for a complete check or about 13 percent of one man's eight-hour watch.

These times and audit frequencies must be contrasted with the probability of detection of an aid discrepancy by pilots or local tow boat operators. By considering the number of vessels expected to pass an aid during the interval between LLLTV audits, an estimate of the probability of discovery of a discrepancy can be made. Since the number of vessels transiting in a 24-hour period could be in the range of 150 to 200, it can be concluded that an aid could be passed as often as six times an hour, with each passage being an opportunity for the pilots or tow boat operators to detect and report the discrepancy. Further, excellent voice communications that they have with VTS appears to expedite the reporting of discrepancies. Thus, the frequency with which these aids are observed by the pilots and tow boat operators nullifies, to large measure, the benefits of a one-time per eight-hour watch audit, because it is highly unlikely that an aid discrepancy should go unnoticed through many passages of knowledgeable pilots and tow skippers. The argument that an audit could be useful in the case where a ship or tow drags a buoy off station, and the next ship or tow fails to note it, and a grounding or other damage is done, is incorrect, as the possibility of discovery of this type of discrepancy by VTS performing a 3-times-a-day audit using LLLTV prior to the casualty is very low. The cost of such an audit would also be considerable both in time and manpower with little tangible results.

### 3.3 Possibilities of Using Radar For Auditing Aids to Navigation

The Houston VTS radar was studied to determine its capabilities to perform visual auditing of aids to navigation. Houston has the AIL (Cutler Hammer) Model CLU 109-V radar.

Radar readings were taken on fixed objects and compared to charted positions (which were "unplotted" using conventional navigation procedures) to determine net accuracy of the system. Readings were also taken from fixed point to fixed point to determine the accuracy of direct measurements with the range ball. Additional readings were taken on floating and fixed aids to determine identifiability and maximum useable range for detection.

The results of these readings are summarized in Table 1A, B, and C.

The actual points used in these readings follow:

Readings were taken on the following fixed objects and the antenna:

TABLE 1A

RADAR STUDY ON FIXED OBJECTS

| EIGHT-MILE SCALE | BEARINGS (degrees) | | RANGE (yards) | | ACTUAL | DIFFERENCE | PERCENT |
|---|---|---|---|---|---|---|---|
| | TESTS | AVERAGE | TESTS | AVERAGE | | | |
| Galveston | | | | | | | |
| South Jetty Light | 095.7 | | 8270 | | | | |
| | 095.9 | | 8320 | | | | |
| | 095.9 | | 8310 | | | | |
| | 095.9 | 095.85 | 8300 | 8300 | 8290.2* | +9.8 | 0.12% |
| Galveston | | | | | | | |
| North Jetty Light | 082.0 | | 9790 | | | | |
| | 082.2 | | 9830 | | | | |
| | 081.9 | | 9760 | | | | |
| | 082.2 | 082.08 | 9760 | 9785 | 9700 | 85. | 1.0% |
| Galveston | | | | | | | |
| North Jetty Seaward | 071.5 | | 6880 | | | | |
| Dredging Tower | 071.5 | | 6870 | | | | |
| | 071.6 | | 6900 | | | | |
| | 071.4 | 071.5 | 6850 | 6875 | 6775 | 100. | 1.45% |
| Houston Ship Channel | 319.5 | | 6730 | | | | |
| Entrance Range | 319.5 | | 6740 | | | | |
| Rear Light | 319.4 | | 6740 | | | | |
| | 319.5 | 319.5 | 6740 | 6737.5 | 6790.8* | -53.3 | -0.78% |
| Texas City Outer | 305.3 | | 6870 | | | | |
| Range "B" Rear | 305.3 | | 6860 | | | | |
| Light | 305.0 | | 6840 | | | | |
| | 305.3 | 305.25 | 6900 | 6867.5 | 6900 | -32.5 | -0.47% |

*Calculated distance by geodetic points. Other ranges measured from chart.

TABLE 1B

RADAR STUDY ON FIXED OBJECTS (POINT BY POINT)

| EIGHT-MILE SCALE | BEARINGS (degrees) | | RANGE (yards) | | ACTUAL | DIFFERENCE | PERCENT |
|---|---|---|---|---|---|---|---|
| | TESTS | AVERAGE | TESTS | AVERAGE | | | |
| South to North Jetty | 213.1 | | 2610 | | | | |
| Lights | 213.9 | | 2570 | | | | |
| | 212.4 | | 2590 | | | | |
| | 213.2 | 213.15 | 2570 | 2585 | 2580 | 5. | 0.19% |
| T.C. Outer Range | 045.9 | | 1660 | | | | |
| Rear Light to H.S.C. | 046.4 | | 1690 | | | | |
| Entrance Range Rear | 044.0 | | 1690 | | | | |
| Light | 047.2 | 045.9 | 1670 | 1677.5 | 1675 | 2.5 | 0.15% |
| S. Jetty Light to | 150.0 | | 3480 | | | | |
| N. Jetty Seaward | 150.0 | | 3490 | | | | |
| Dredge Tower | 150.0 | | 3500 | | | | |
| | 149.6 | 149.9 | 3470 | 3480 | 3480 | 0. | 0.00 |

TABLE 1C

RADAR STUDY ON AN (FROM ANTENNA)

| FOUR-MILE SCALE | BEARINGS (degrees) | | RANGE (yards) | | CP RANGE | DIFFERENCE | PERCENT |
|---|---|---|---|---|---|---|---|
| | TESTS | AVERAGE | TESTS | AVERAGE | | | |
| Galveston Anchorage | 045.6 | | 3830 | | | | |
| Lighted Buoy B | 046.1 | | 3840 | | | | |
| | 045.9 | | 3830 | | | | |
| | 045.9 | 045.9 | 3830 | 3832.5 | 3880 | -57.5 | -1.50% |
| Galveston Anchorage | 071.3 | | 6310 | | | | |
| Lighted Buoy A | 071.3 | | 6310 | | | | |
| | 071.1 | | 6330 | | | | |
| | 071.1 | 071.2 | 6300 | 6312.5 | 6200 | 112.5 | 1.80% |
| Galveston Entrance | 082.8 | | 7230 | | | | |
| Channel Lighted | 082.9 | | 7220 | | | | |
| Buoy 7A | 082.8 | | 7230 | | | | |
| | 082.8 | 082.9 | 7200 | 7220 | 7200 | 20.0 | 0.28% |
| Galveston Freeport | 326.0 | | 4650 | | | | |
| ICW Buoy 2 | 326.0 | | 4640 | | | | |
| | 326.0 | | 4620 | | | | |
| | 325.9 | 326.0 | 4630 | 4635 | 4625 | 10.0 | 0.22% |
| SIXTEEN-MILE SCALE | | | | | | | |
| Houston Ship Channel | 330.6 | | 18060 | | | | |
| Pipeline Marker LT 47 | 330.3 | | 17990 | | | | |
| | 330.7 | | 17990 | | | | |
| | 330.5 | 330.5 | 18050 | 18022.5 | 19095 | 72.5 | 0.99% |

General Comments on Table 1

1. Typical time required to take readings was 20 to 30 seconds.
2. The difference between actual and observed range for the fixed objects was between 0 and 100 yards or an average of 0.44 percent of actual range. Bearing difference (average to tests) was 0.33 degrees overall average.

South Jetty Light
North Jetty Light
North Jetty seaward dredging tower
Houston Ship Channel Entrance Range Rear Light
Texas City Outer Range "B" Rear Light
Houston Ship Channel Light 47

Readings were taken on the following floating aids from the antenna:

Galveston Anchorage Lighted Buoy B
Galveston Anchorage Lighted Buoy A
Galveston Entrance Channel Lighted Bell Buoy 7A
Galveston-Freeport ICW Buoy 2

Readings were taken from the following - point to point:

North Jetty Light to South Jetty Light
Texas City Outer Range "B" Rear Light to Houston Ship Channel Entrance Range Rear Light

A test was also made to measure the display (PPI) size of an aid. On the scale, Galveston Bay Channel Buoy 12 was measured across the blip with the radar range ball. The apparent width of the contact was 40 yards and the length about 20 yards.

The following candidate methods for auditing aids to navigation were identified:

1. Electronic AN "Maps" Method:

   The radar has the capability of being programmed with five separate maps (electronically retained reference lines). Each map can provide 80 lines or segments (a line or segment is defined as a straight run between two points irrespective of distance and can be solid or broken). Houston now uses electronically generated lines to delineate the main channel on one map, but has plans to provide an AN map using the electronically generated lines (two lines per aid) to identify each aid station.

   Provided the assigned charted positions are programmed into this map rather than visually observed positions of the aids, this would provide a quick method of comparing actual aid locations to their charted positions.

2. Transparency Overlay Method:

   In the case where the electronic map is not available, an overlay could be constructed with proper reference points and assigned charted position of aids.

3. Visual - Cursor Set-Up Method:

   This would require each aid to be identified and readings taken from it. Those readings would then be compared to a tabulated list of the assigned charted position range and bearing to each aid.

In evaluating these methods, the manpower requirements and equipment capabilities, with regard to net benefit, should be considered.

The electronic AN map would require virtually no additional manpower to use in visual auditing of aids to navigation. If the VTS radar has this map capability, it should be used. The transparency overlay method would take longer and be more cumbersome to use and should only be considered if no electronic maps were available. The cursor setup method would require a formitable effort and an additional expenditure of manpower.

Any of the above auditing methods would be subject to radar error, PPI display limitations and operator interpretation. With those factors in mind, the radar may still not provide the accuracy required of a precise audit of buoys.

## 4.0 GENERAL CONCLUSIONS

Based on our observations of the VTS watch procedure and the LLLTV and radar capabilities, a rigorous visual auditing program of buoys in Houston would not be practical for the following reasons:

1. The high frequency of transiting vessels may have a better probability of detecting an aid off-station or not watching properly than a one or two time per watch audit at the VTC with their present capabilities. Voice communications are excellent and a constant factor throughout the channel.

2. The visual observation of aids possible with the LLLTV would only be a rough check but could possibly help in verifying "off-station" reports. LLLTV is also limited by factors covered earlier in this report.

3. The radar observation of aids through the visual PPI display is much better for auditing aids than LLLTV but it has a severe limitation. A large part of the limitation is due to the PPI display characteristics, operator interpretation, and radar error.

4. Not all aids can be observed with LLLTV or radar and no aid has coverage of both LLLTV and radar.

5. VTS does not presently have the equipment or the manpower to conduct an aggressive and accurate auditing program.

6. The radar being used by and planned for use by VTS, AIL Model CLU 109-V has the inherent capabilities to be used as an auditing tool. The average range random error is $\pm 25$ feet and average azimuth random error is $\pm 0.3°$. The limiting factors, at present, seem to be the visual display on the PPI, operator interpretation, and its single antenna input, as well as the absence of geodetically tied horizontal control.

## 5.0 RECOMMENDATIONS

1. As an interim possibility, all existing VTS radars could be programmed with an AN map of digitized aid charted positions. This would provide a quick station check without any increased manhour requirement. Indications are that, depending on the specific VTS and actual radar tower locations, as few as 15 to as many as 100 floating aids could be audited in this manner. It would neither be practical nor desirable to provide transparency overlays for the radar when it has the electronic map capability. It will be necessary also to map the geodetic positions of several reference fixed landmarks for calibration purposes.

2. A visual scale photographic library could be constructed and fitted in a quick reference roller type of index. This could be available at the operator's console for visual comparison on the LLLTV console of actual aid positions against the aid position on the "standard" view. Such a procedure would be useful as a check against gross position errors only.

3. A transparency overlay library could be constructed for use on the 19-inch monitor and in conjunction with the standard view index. The net positive effect of this overlay audit is to a great degree obviated by the constant communications with the many passaging vessels. (See Figure 4.)

4. Aids to navigation auditing capabilities should be considered in the next generation of VTS equipment design. It could also be considered in modification ideas for the existing equipment.

5. Future development and modification of VTS's could provide greater benefit to the buoy audit task if the VTS program were to obtain audit accuracy specifications from the aids to navigation program.

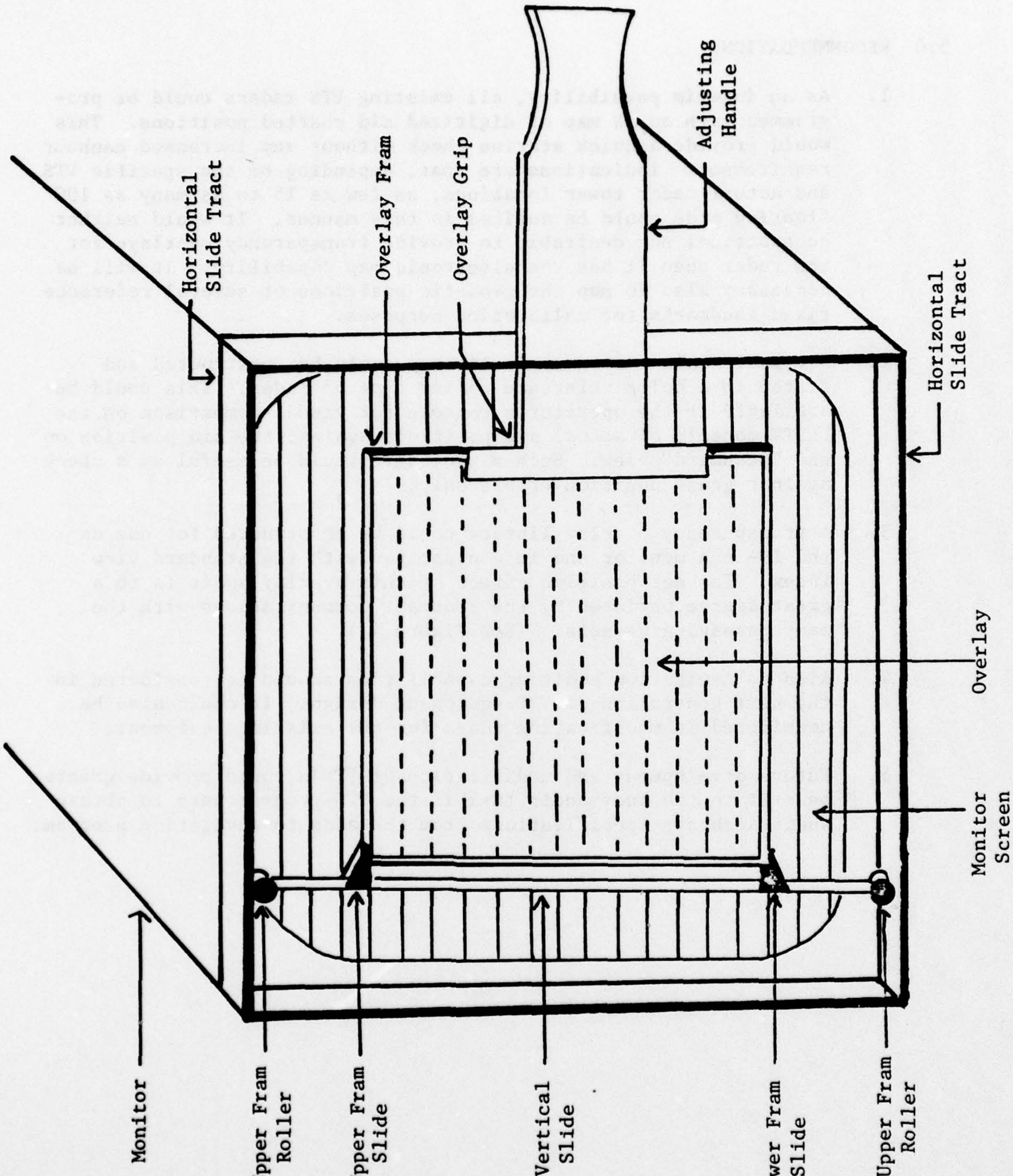


FIGURE 4

PROPOSED OVERLAY DEVICE FOR LLLTV



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