Multiple Image Integration Printer

Design Plan for Phase II

October 1966

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1. INTRODUCTION

This program on Image Integration techniques was initiated in April 1965 and consists of two phases. Phase I comprised a study of methods of electronic image integration using automatic image registration and video processing. Automatic image registration has obvious advantages in allowing material of different geometry to be integrated. Video processing allows image characteristics such as contrast, highlight detail and shadow detail to be optimized for combination with other inputs. Circuitry for this purpose was developed and tested on the ARES viewer.

Phase I also included a design study for a 3-input image integration viewer/printer with 3000 line resolution. The output of this system consisted of a 3 x 3 inch transparency of the integrated image at a magnification between 3.7x and 12x with a limiting resolution of about 100 lines/mm referred to one of the inputs. The proposed instrument and its expected performance were described in the report on Phase I which was issued on 6 December 1965, and the supplement which was issued on 8 April 1966. It was found that little improvement in resolution could be expected from the integration of fine grain aerial photographs. However, potential advantages exist in the interpretation of integrated imagery due to the increase in contrast, reduction of noise, and addition of more detail.

At this stage it became apparent that the advantages to be gained by image integration and the techniques required to obtain optimum results had not yet been sufficiently well established to warrant fabrication of an operational Image Integration Viewer/Printer. In this respect, theoretical investigations and performance predictions are of limited value because of the difficulty of setting up adequate mathematical models of photographic imagery. An experimental approach is therefore necessary to determine the value of image integration.

For the second phase of this contract therefore, [redacted] proposes to place the STAT main emphasis on an experimental investigation of the advantages that accrue from multiple image integration. An electronic imaging system will be used because of the greater flexibility it offers in video processing.

An electronic image integration system will be designed and built in the laboratory to accept 3 inputs and to make a hard copy of the integrated image using a 3000-line scanning system. This equipment will be used for a comprehensive test program in which an evaluation of the benefits of image integration to the general problem of photointerpretation will be thoroughly investigated. The results of this investigation will enable a decision to be made as to the future desirability of developing operational image integration equipment.

2. PROPOSED MULTIPLE IMAGE INTEGRATION PRINTER

2.1 General Description

A block diagram of the proposed MII printer is shown in Figure 1. The unit consists of three input scanner assemblies, designated channels A, B & C, a high resolution printout assembly and a visual monitor. In addition, correlation and transformation circuitry allow corrections to be applied automatically and/or manually in order to register images in the three channels. When the images have been registered, video processing circuitry permits the integration of up to three images at the print-out station.

In operation, an image, designated the master, is placed in the channel A scanner assembly, and the desired target area selected. This channel does not have transformation capability, therefore the other images must be registered with reference to the "master" image. A second image containing the target area may be placed in scanner assembly B and automatically registered with A when it is within pull-in range. In similar manner, a third image C may be registered with A. The low resolution monitor will be used for initial adjustment to obtain the target area and will also indicate approximate registration. In order to adjust for exact image registration, a "correlation quality" meter will be provided. This will enable very small registration errors beyond the resolution of the visual monitor to be detected. Fine manual adjustments of parallax and transformations may then be made in order to maximize the correlation quality reading.

The main difference between this equipment and the viewer/printer described in the Technical Report on Phase I dated 6 December 1965, is that a high resolution flying spot scanner will now be used in place of the image dissector tube and follow-spot illuminator previously proposed. The improvement in resolution offered by the latter system was marginal and it is a highly expensive technique still in the development stage. The use of a more conventional flying spot scanner will offer greater flexibility.

A further improvement in the presently proposed equipment is the use of the same crossed diagonal scanning pattern both for initial correlation and for high resolution readout. This will enable the size and shape of the scanning pattern to be controlled much more easily in the high resolution mode. A further advantage is that accuracy of registration can be continuously monitored right through the readout cycle. Instead of an analog memory, the transformation errors will now be stored in digital form. The video processing, correlation circuitry and readout systems will remain substantially as before.

Due to the high resolution requirements, the air bearing film handling system accepting 9½ x 9½ film will be replaced by precise X-Y micrometer drives capable of accepting film chips up to 2½ x 2½ inches at each of the 3 input stations.

2.2 Scanner Assembly

Each scanner assembly includes a CRT, photomultipliers, video amplifier, deflection amplifiers, optics, X-Y stage and drive. The CRT selected will be similar to the WX-4647P16 which provides a 1 mil spot diameter at half amplitude. The optics will reduce the raster 10:1 at the image thus giving a nominal scanned area of about 5mm x 5mm with a 2.5 micron spot diameter.

A summary of the scanner parameters is given below.

1. Area scanned on film; max., 7mm x 7mm.
   (at 10:1 reduction) min., 3.5mm x 3.5mm.

2. Expected video S/N 30 db.
3. Frame time, print 4.5 seconds.
   monitor 1/30 second.
4. Raster, dual diagonal scan
   print mode, 3000 TV lines
   monitor mode, 500 TV lines

2.3 Print-out Capability

The output CRT similar to the input CRT will be used, with a P11 phosphor, providing high efficiency. The line width at half amplitude will be approximately 1 mil., and a 3 in. x 3 in. raster will be employed. A 4 x 5 inch camera will be provided to record the output, on either Polaroid or standard 4 x 5 cut film. Print time will be equal to one complete scanning period, or 4.5 seconds.

2.4 Video Processing

The automatic registration of several aerial photographs of the same area taken under different conditions of illumination is sometimes difficult because of the presence of shadows or specular reflections. Shadows are a dominant feature of photographs taken with sunlight falling on the area from a low angle. Specular reflections, while less common, cause obliteration of significant detail due to saturation of the photographic material. If the shadows in the several photographs are in different positions due to a change in the position of the illumination source, or are present in only a few of the inputs, correlation is difficult to achieve. A great improvement in the operation of automatic registration circuitry can be realized if the effects of shadows can be eliminated.

Electronic scanning allows great flexibility in processing of video signals prior to print-out. For example, some of the techniques which may be employed include black level clamping, variable gamma control and detail sharpening. In addition, the mixing of video from up to 3 channels may be carried out by straight addition or by more complex techniques using majority voting or weighting. The design of the MII printer will allow various video processing techniques to be investigated.

The first stage of the video processor will consist of a pre-amplifier with polarity selector that will enable the display of either positive or negative material. The second stage of the video processor will consist of two non-linear amplifiers in parallel. One amplifier produces a video signal which is the square root of the input, the other produces a video signal which is the square of the input. To establish a constant operating point, a keyed dc clamp is provided which sets the operating point for the two non-linear amplifiers during the blanking period which is at the turnaround of the scanning lines.

The outputs of the two non-linear amplifiers are fed to the two inputs of a mixer where they are combined. The overall response can then be controlled by varying the proportions of the "square root" and "square" signals that are combined. By this means a continuous control of gamma between 0.5 and 2.0 is obtained. The signal from the gamma amplifier is then fed to the aperture corrector. This compensates for the gaussian shape of the scanning spot, and can also be used to increase image sharpness. The amount of correction that can be introduced is limited by the increase in noise that can be tolerated. In general it is safe to assume that an approximate 6 db boost can be used at the higher frequencies resulting in a noticeable increase in sharpness in the reproduced picture.

2.5 Correlation & Transformation

Video signals from channel A (master) will be correlated with both channel B and channel C in turn. The orthogonal correlator provides parallax error signals for X-Y stage drive, as well as the basic signal for further analysis into first- and second-order distortion components. A "normal" correlator provides a signal output which is proportional to the quality of correlation between the two images. This operates even during the high resolution print-out cycle, so that image registration can be constantly checked.

Distortion corrections, which include all 1st and 2nd order corrections, are applied to channel B and C scanning rasters by means of modulators. The magnitude of the correction is controlled initially by the error signals developed automatically from the distortion analyzer, and then manually if required from controls set by the operator.

Automatic registration is carried out only in the "monitor" mode at a frame rate of 30 c/sec. Manual adjustments may be made to all corrections by peaking the correlation quality signal.

Sequential sampling of the error components and a serial memory to store the magnitude of the error signals is provided in order to simplify the electronics involved and to permit stable steady-state corrections to be applied to the scanning rasters during print-out.

2.6 Resolution Considerations

Various factors influencing resolution can be predicted in advance; however, the final performance of equipment can only be evaluated by running tests on the system response for known inputs. A calculated system MTF can be obtained from the scanning CRT spot size, optics response and print-out CRT spot size. Assuming the use of optics which have a limiting resolution of 200 l/mm, the CRT will produce an equivalent resolution at a spot diameter of 1.6 mils with a 10:1 reduction at the image. The individual and combined responses are shown in Figure 2, giving a limiting system response of about 115 l/mm., referred to the input.

A CRT spot size of 1 mil would provide somewhat higher system response. There are, however, many factors influencing the actual spot size obtained and the 1.6 mil figure may be more realistic.

3. STATEMENT OF WORK

The proposed program will consist of the following specific tasks:

1. Design and construct a laboratory model, 3-input Image Integration Printer as described in Section 2. (6 months)
2. Check-out and evaluate equipment for resolution, signal/noise ratio, stability, correction accuracy, operator convenience. (2 months)
3. Using the above equipment, evaluate multiple image integration with various source materials to be specified and supplied by the customer (3 months).
4. Prepare a Final Report. (1 month)

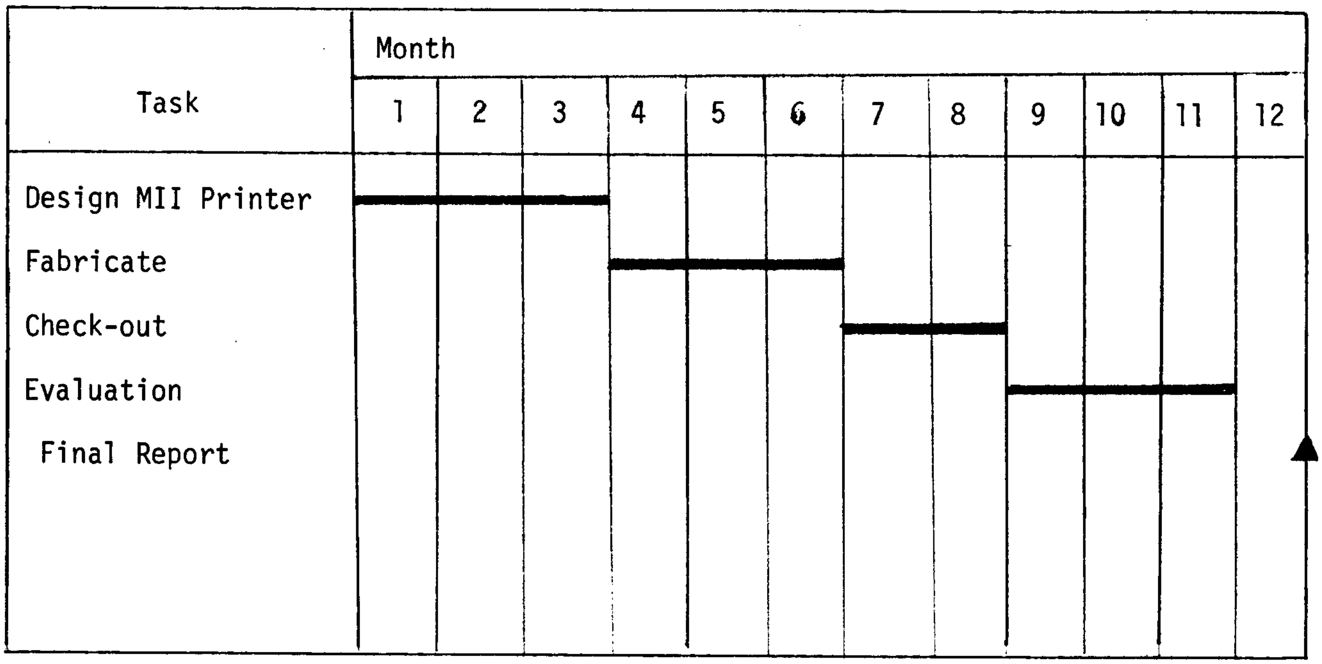
The period of performance for this work will be 12 months. A schedule of work is shown below.

Deliverable items will be as follows:

11 Monthly letter-type progress reports due on or before 15th of following month.

5 copies of Final Report due within 30 days of completion of contract.

SCHEDULE



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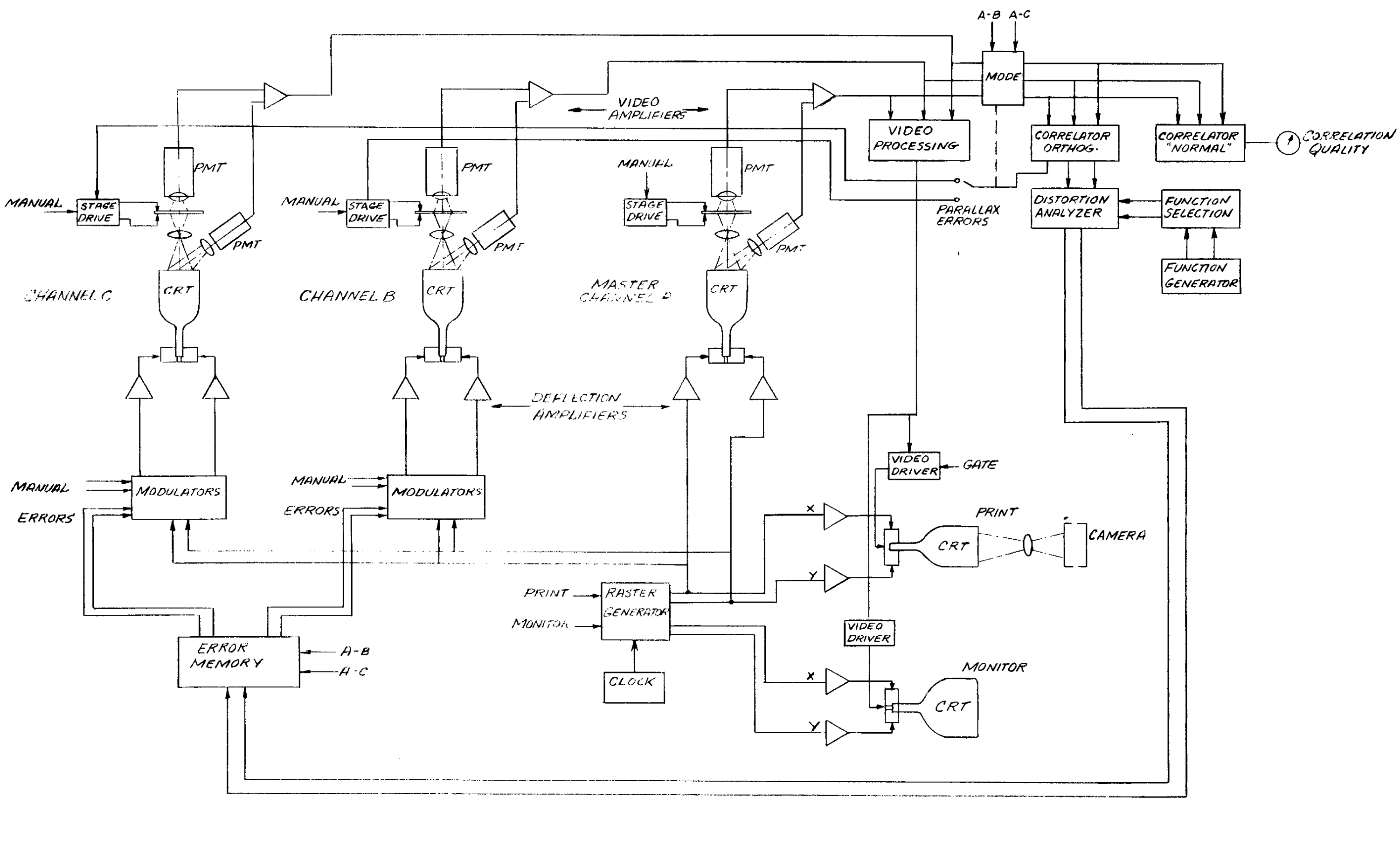

FIG. 1
BLOCK DIAGRAM
MULTIPLE IMAGE INTEGRATION PRINTER

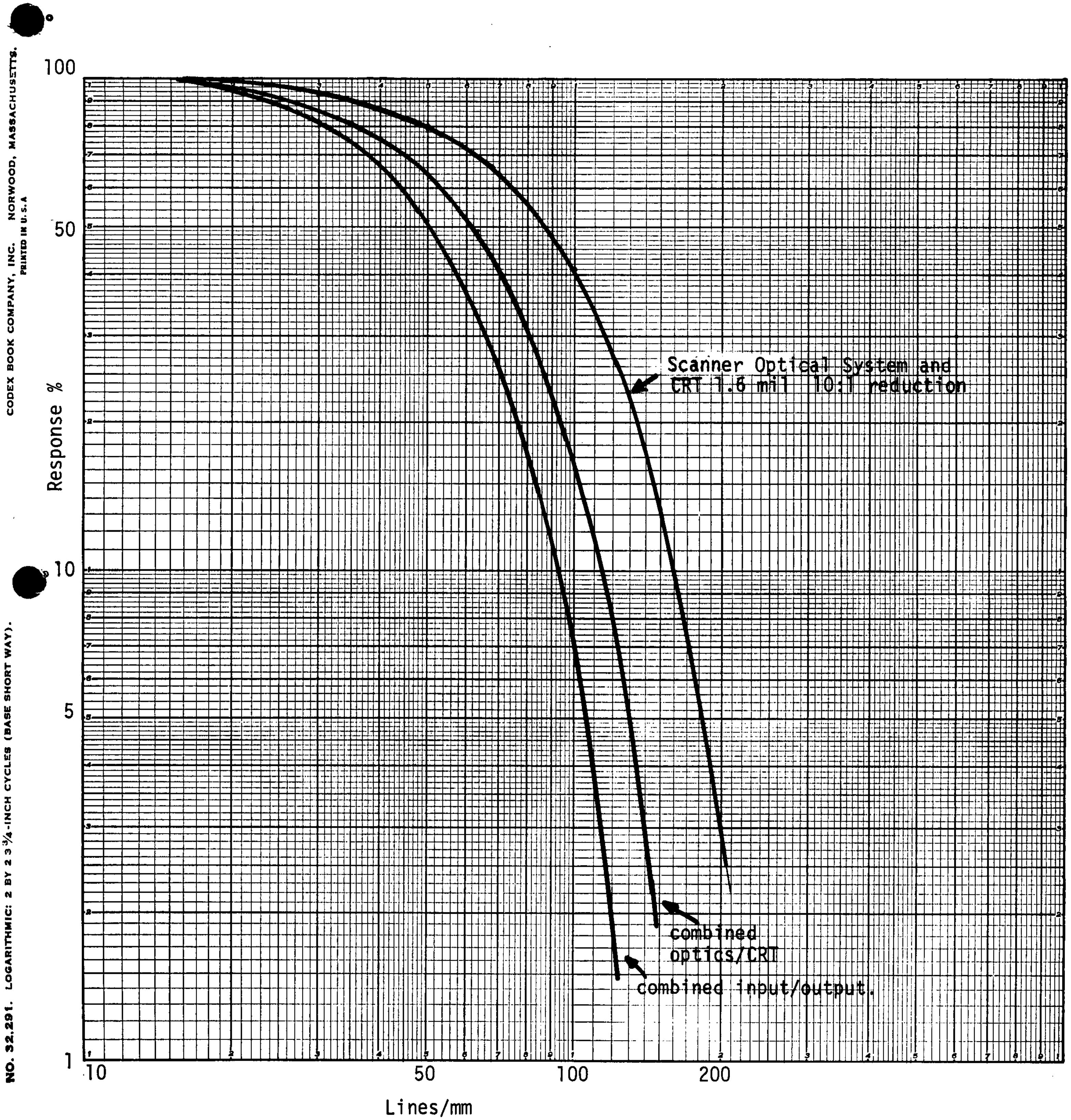

Figure 2. Calculated MTF for system

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