Visit to Hitachi Image & Media System Lab, September 3, 1991

This meeting was a follow-up to the June 11 visit and was arranged by Mr Ohashi. Attendees were his PERL colleagues Mr Okamoto and Mr Matsuzaki, plus Mr Hayakawa from the CAE Systems Lab and four I&MSL people. The general subject was how are computers used in the early design of complex tape handling mechanisms for videocameras, and what is difficult about such designs.

The Tape Transport Design Problem

The tape transport mechanism is very complex and very small. Its job is to carry a section of tape from the cassette to the read / write drum and wrap it more than halfway around. It must adhere to remarkably close tolerances in those places where it positions the tape against the head: since record tracks are about 10 microns wide, the tape must be positioned within a micron or so. There is a guide ridge on the base of the drum for this purpose. As a result, the main requirement is that the tape be gently pressed against this ridge and no wrinkles develop in the tape. In addition, the tape is skewed in space with respect to the spin axis of the drum. In Hitachi's design, this requires that the tape be skewed in the read-write position with respect to its stored position in the cassette. See Figure 1. The tape transport mechanism must therefore carry the tape from a straight horizontal condition to a skewed condition wrapped around the drum. See Figure 2. The path the tape follows in space is also important, especially as soon as the first portions of the tape begin to contact the drum.

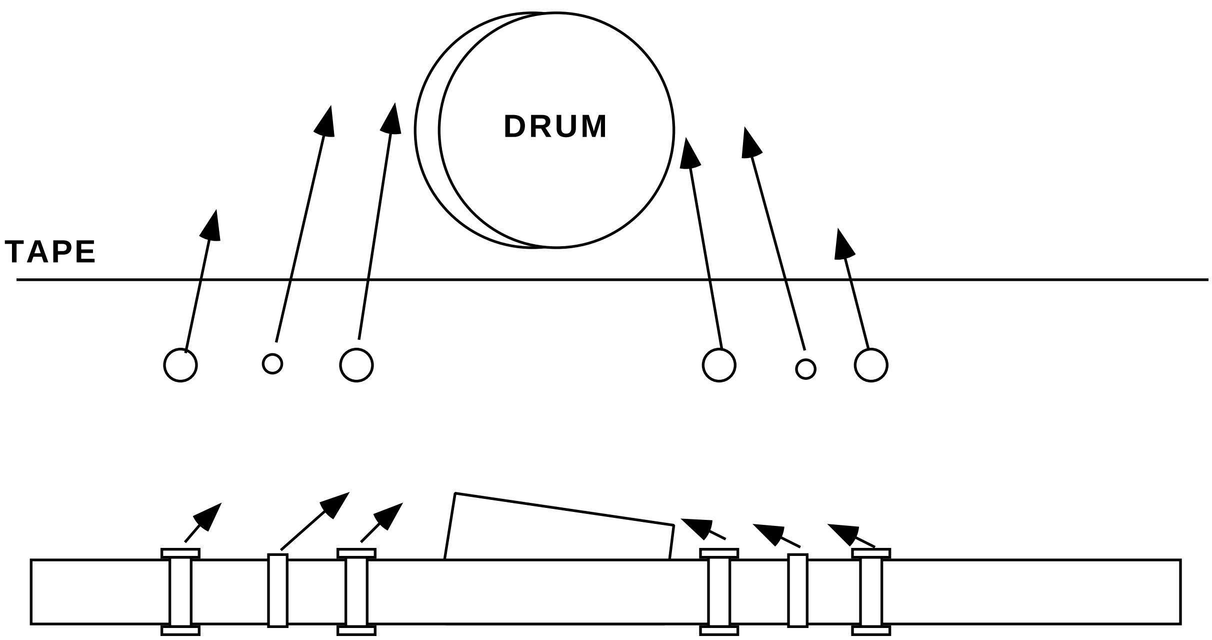

Figure 1. Tape Before Threading onto Drum

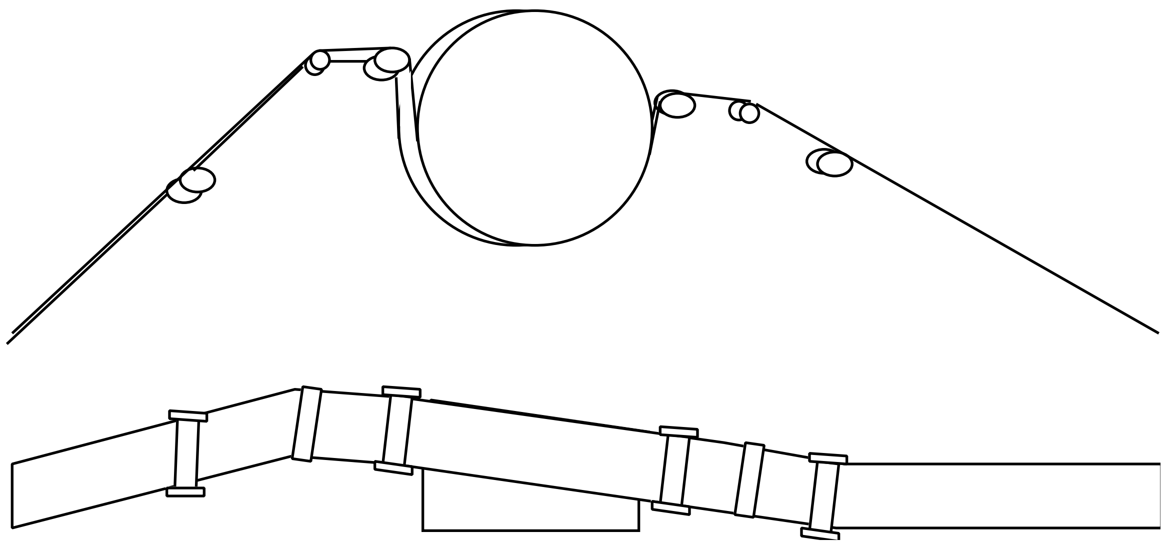

Figure 2. Tape After Threading onto Capstan

The transport mechanism consists of several stationary guide posts and freely spinning rollers which are mounted on moving or hinged metal pieces. These posts and rollers pull the tape out of the cassette and toward the drum. Linkages and gears provide the motion, driven by a motor and several belts. The transfer from horizontal to skewed is provided by several precision plastic cams which lift the roller carriers as they move. The linkages and gears are arrayed in several horizontal layers on the bottom of the mechanism, plus a few parts on two sides. The top hinges up to allow the tape to be installed and thus has no moving parts on it. There are about 240 parts in this mechanism including about 50 screws and rivets. Very few parts are provided as subassemblies to the final line, which has about 100 automated or semi-automated stations.

Design of such an item requires planar mechanism synthesis, cam design, spatial path planning, and stress-strain analysis of very thin material. Especially interesting was the use of FEM to predict the shape of the tape after the drum begins spinning; friction and skewness combine to bend the tape slightly in its own plane. This will cause it to wrinkle unless the guide rollers are positioned slightly differently from purely geometrically determined locations.

The main tools available are 3D CAD (Hewlett Packard ME 30) plus SDRC's I-DEAS and associated FEM software, plus Hitachi's own drafting software.

Design Procedure

The description of the procedure was confused between how the current product was designed and how the latest one is being designed, since ME 30 was acquired in the middle of the last design and not used during design of the first prototype. So the procedure outlined below is really how the next one will be done.

First, a concept is generated that includes defining the specifications and architecture. Then a layout of the tape transport parts is attempted and basic dimensions such as hole spacings and slot sizes are determined. The mechanism parts are then modeled and displayed in 3D CAD so that the motion and interferences can be checked. This is a painful process now since ME 30 does not support the necessary constraints or animation. I-DEAS Level V, which they have, might be able to support this. At this point about half the required parts are represented.

The 3D model is converted automatically to 2D, and drafting is done to create information from which prototype parts are made, usually by hand. These are assembled into the first prototype, mated to a drum designed by others, and tested. Results are fed back, the layout is revised, and the cycle repeated for a second prototype.

During the previous design cycle, the first prototype was not designed in such a neat sequential manner, although the second was.

Producibility and assembleability are considered during the first prototype for a few key parts. Also, because of size restrictions, low profile fastening methods were mandated from the start. This means either staking and riveting, or use of very small flat head screws. Fastening big parts like motors is a problem when such small fasteners must be used.

Critical decisions like tolerance assignment are done manually according to the designer's experience. There are no cost-tolerance models, and the simulations do not take tolerances into account. The main factors determining tolerances have been discussed above.

Future Design Tool and Methodology Needs

Two areas stand out: increased use of parametric design and "rationalization of the conceptual design process."

Parametric design means having an equation-driven design process in which one can input certain parameters and have the computer adjust others to suit. This method seems appropriate to what is normally called variant design but not to what the Hitachi I&MSL people have been doing, which usually requires all new parts and part shapes. Often when I asked companies if they used past design data they said no because new designs are so different. Thus I cannot be sure why Hitachi is emphasizing parametrics in the case of VCR's for videocameras.

Rationalization of the conceptual design process means raising it above the level of sketching and cosmetic design illustration. Mr Matsuzaki seems to recognize the potential for feature-based design to provide some of the needed structure. As it is, conceptual design of novel products is undisciplined and results in odd-shaped parts. More generally, standardization of the design process is needed.

He is currently reviewing his department's use of concurrent engineering. What else is there besides weekly meetings, he asks? What is the potential for computerized CE, especially for companies with a long tradition of close communication and small design teams? He is actively afraid that computerized CE will spoil Japan's ability to design.

I asked if this means he does not think computers can help product-process design. His reply indicates an important area of potential confusion that I met at other companies: they want CAD/CAE/CAM so that they can improve product-process design integration with focussed engineering tools. "Computerized CE" means computer tools strictly for communication between designers, a very special case. The latter is unpopular, but the former is essential.