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In the past fifteen years, aircraft technology has climbed past the sound barrier and moved deeply into supersonic speeds. General Dynamics has built thousands of military and commercial aircraft and pioneered many aerodynamic advances. Within the most recent generation, the Corporation has developed and produced: the first operational supersonic aircraft, the first supersonic bomber, the first aircraft designed for commercial freight, and the first operational variable sweep-wing aircraft.

Electronics is the nerve system of modern technology. General Dynamics builds a broad range of electronic equipment and systems. Its products are in use on land, on and below the surface of the sea, in aviation, and in space. Current major programs range from ground and airborne navigation and air traffic control systems to aerospace ground support and maintenance systems. In addition, tactical radio and surveillance systems, electronic-countermeasures systems, radar and sonar systems, direct view displays for computer data, and high-speed print-out devices—also products of General Dynamics—play leading roles in our modern electronics-directed technological advances.

Guided missiles have assumed a growing importance in defense against high-performance enemy aircraft. General Dynamics has built several generations of surface-to-air guided missiles for use aboard ships and by ground troops. It also produces a variety of tactical support equipment.

It is only fitting, then, as aircraft technology, electronics, guided missiles, and other aspects of the Aerospace Age have advanced, that logistic support—the foundation of good operation and, consequently, success and progress—has also undergone metamorphosis.

The wheel of scientific change is whirling faster than it has at any other time. And logistic support will continue to keep abreast of change to meet the myriad demands of the future.
General Dynamics' experience in the pilot line approach to development and production of high-density aircraft has proven the benefits of a close "on floor" working relationship between Engineering, Tooling, Manufacturing, and the various support departments. In order to compress span time between Engineering design and completion of the actual end item, it is essential that two-way channels of communication be established to permit potential changes to be analyzed and planned without interrupting actual operations on the production line. These changes may be prompted by engineering, producibility, assembly sequencing, procurement, crewloading, quality or cost reduction reasons.

A typical example of this coordinated effort is the use of the Engineering, Tooling and Manufacturing Aids, located in a centralized ETMA area. Here a group of professional, technical, and skilled representatives from Engineering, Tooling, Quality Control, Factory, Manufacturing Control and Operations Management work side-by-side under the direction of the Factory Manager, with a prime objective of shortening span times.

ETMAs are full-scale jigs or models of major components or sections of the end product that incorporate critical tolerances, dimensions, materials, and configuration requirements. They are constructed for the purpose of allocating space for equipment and systems, and for routing of tubing, ducting, electrical harnesses, control cables, and for upholstery. These items cannot accurately be portrayed on two-dimensional blueprints. Dimensionally accurate detail and subassembly mockups are made using the ETMA to eliminate installation interference, determine tool requirements, and decide on design correction improvements or revisions prior to and after final Engineering release. ETMAs are also used as visual aids in making functional demonstrations of a simulated end product and, as such, serve as an advance training unit.

ETMAs enable the discovery of manufacturing and installation problems in time to permit management to make necessary alternate decisions and still maintain the original schedule. Formability and weldability of materials; quick disconnect location problems; establishing and confirming interchangeability and replaceability points; and determining the need for hagouts or weldments until materials, castings and forgings are available, can all be resolved on the ETMA. Valuable leadtime is gained in support planning activities by its use in determining the type of production aids and Aerospace Ground Equipment configuration required.

Through study on the ETMA and using crewloading and line balancing techniques, congested work station areas are relieved. Off-ship subassemblies and systems packages are created and checked on the ETMA. It is then determined if these items can be sequenced for installation at a later point, permitting more efficient utilization of personnel and minimizing damage to critical parts during primary and final assembly operations.
ETMA teamwork has been established through experience on such programs as the B-58, F/TF-102, F-106B, B-58 TCP pod, and the B-58 escape system. This teamwork played a major role in the development and delivery of the first F-111 on schedule and subsequent major configuration changes thereafter, such as airplanes 12, 19, and 31.

The ETMA made it possible to resolve all geometry problems associated with movable surfaces and wing sweep on the No. 1 aircraft which otherwise may have resulted in a four or five month delivery penalty. Also, loss of work-in-process due to unproven designs, a major cost item, and increased span times due to corrections and reordering of high-dollar piece parts and assemblies, were greatly reduced.

By simulating the dense and complex areas such as the cockpit, wheel well areas, upper deck trough and missile bay routing areas, the engineering designs and required tooling were finalized with a high degree of success.

The primary advantages of the ETMA to Engineering lie in the category of undimensioned tubing and electrical harnesses, in that the ETMA offers the engineer an opportunity to determine tubing and wiring lengths, shapes, routing, and location, plus the size of support bracketry and fittings. It provides a means whereby wiring can be grouped according to specific requirements, such as RFI coding, harness size versus space, etc. On the ETMA, it is also possible to determine the feasibility of installing and maintaining these systems.

In the area of dimensioned tubing or ducting, the engineer can evaluate space requirements, installation feasibility, and maintainability of various systems. The design of complicated contour parts can be evaluated on the ETMA prior to the formal release by Engineering, and any corrections or revisions can then be made. The installation of survival and personnel equipment stowage can be evaluated for accessibility and proper utilization of space.

The customer finds the ETMA a useful article in evaluating anticipated changes such as the gunsight presently under evaluation.

As a result of ETMA disclosures, many tangible savings have been recorded. A primary one is that the mockup cost on the first aircraft would have been 1½ times the cost of the ETMA. Also, there have been engineering and production improvements of thousands of items. These changes
were made prior to the manufacture of parts, resulting in a saving of labor and materials.

Also, many intangible savings are realized from the ETMA in the area of Engineering corrections or changes where preliminary drawings or sketches are used on the mockup, and any revisions that are necessary are incorporated prior to formal Engineering release.

General Dynamics, Fort Worth Division; Grumman Aircraft Engineering Corporation; and McDonnell Aircraft Corporation utilized the ETMA in analyzing interface problems on major structure. This enables the Engineering and Manufacturing people to ferret out sequence and interference problems that in all probability would not have been recognized until the major components were physically mated together. Considering the complexity of the major break points at Station 593 (Grumman/General Dynamics interface) the initial airplanes have been joined with minimum trouble; however, structural tie-ins are being progressively simplified by Engineering to permit tolerance washouts and decreased span time associated with major mating.

Another of the major advantages of the ETMA is the intermarriage of vendor specification items such as manifolds, high-pressure steel ducts, valves, equipment racks, etc. Since specification items are normally fully dimensioned by the vendor, changes have to be made at the mockup level to complete this interrelationship; again, the ETMA provides the capability whereby these conditions are incorporated on a timely basis.

Early in the program, the ETMA proved particularly helpful in assuring the validity of design of major moving components, such as wing sweep, landing gear, flaps, etc., where movement geometry affected tubing swivels and harness bending. Space clearances and relationships were proven, especially those critical in nature, where layout was virtually impossible to establish.
The crew module mockup has aided in evaluating the arrangement of environmental control system tubing, pneumatic lines, oxygen lines, electrical harnesses, etc.

A detailed cockpit mockup has continually enabled the Flight Department to evaluate cockpit arrangement; location of instruments, handles, and control mechanisms such as rudder pedals, wing sweep control levers, throttle quadrants, etc.; and seat adjustment comfort and accessibility.

Complete and detailed engine mockups have played key roles in the prefitting of ducts, tubing, hydraulic lines, and harnesses on the engines. In addition these mockups have enabled cavity checks for evaluation of compatibility of the engines to the airframe.

The above experience has pointed out advantages of an active ETMA relative to mocking up the original flying article prior to delivery, but it has been found on other programs, such as the B-58, that an ETMA is an absolute requirement for developing changes on an active program. The importance of an ETMA was strongly emphasized when an Industrial Management Assistance Survey Team praised the ETMA approach for the 111 Program and recommended to the Department of Defense that this be made a requirement on future airframe contracts. Setting aside selected airplanes by major effectiveness points or developing necessary information on work-in-process aircraft is prohibitive because of the high-dollar inventory in tooling, hardware, and facilities, and in most instances would affect delivery schedules on such selected aircraft.

Probably one of the greatest contributors to a successful weapon system program is the ability to isolate skilled technicians, engineers and management personnel so that design and hardware development problems can be resolved by specialized skills rather than by absorbing the impact of the problems throughout the engineering, procurement, tooling and manufacturing organizations.

In summary, learning curves are only as good as the accuracy of engineering designs and the quality of tools that are used to produce the article. Changes and improvements in a weapon system are a way of life because of the aircraft's operational environment. Therefore, change reaction capability must be fast, timely and above all "right the first time." The modern weapon system is a sophisticated article and the state of the art demands ETMAs.
The September issue of the 111 LOG featured the Subsystem Simulation Model (SSM)—one of the three models composing the Maintenance Analysis and Review Technique (MART)—in the first of a series of articles on individual math models developed by the Operations Research Section of General Dynamics, Fort Worth Division.

This month, the second article in the series features a discussion of the Network Analysis Model (NAM).

In the NAM, a network analysis procedure similar to that associated with the Program Evaluation and Review Technique (PERT) concept is used to determine the sequence of maintenance activities best fitted for use in obtaining a minimum turnaround time in a perfect logistic environment (adequate spares, personnel, equipment, and facilities available 100 percent of the time). The simulation is accomplished by combining all of the subsystems into a PERT-type network wherein the occurrence and duration of any subsystem maintenance activity is represented as a stochastic variable.

The model is designed:

1. To use measured or predicted maintenance requirements to determine the best sequence of maintenance activities in terms of minimum turnaround time, and

2. To measure the contribution of the various subsystem activities to such turnaround time.

NAM OBJECTIVES

When the frequency, span time, and assets required for subsystem maintenance have been established by the use of SSM, the next step is to sequence the maintenance activities in terms of the various subsystems that make up the complete weapon system. The Network Analysis Model (NAM) is used to evaluate turnaround sequence options which are determined by the series and parallel maintenance activities for the various subsystems.

The NAM is an extension of the Program Evaluation and Review Technique (PERT) in the sense that PERT is a special case of this model. As in PERT, the assumption is made that the task under analysis is composed of a set of sequenced activities that can be represented as a network. (See illustration.) NAM is different from PERT in that the occurrence of any activity is a stochastic variable, as well as the span time; furthermore, the distri-
butions of the time spans are not restricted to the Beta distribution.

There are many ways in which the sequencing of maintenance of the subsystems could be performed. There are many constraints, too (for example, operation of one subsystem may be required for performing maintenance on another), and selection of the best path is not intuitively obvious. The sequencing is accomplished in the model by establishing a distribution of expected downtime in a perfect logistic environment when all subsystems characteristics are known. The result is a maintenance span time bogey to be attained when personnel, spare parts, AGE, and assets are available. It can be expected that, due to a shortage of assets, field experience will always indicate turnaround time in excess of that indicated by the model; however, field experience should be approximated by the Base Maintenance Operations Model (BMOM), in which the complete weapon system is simulated in a real-world operational environ-

ment and in which realistic turnaround time and assets requirements are determined.

The model is also used to provide a subsystem ranking of time contribution to turnaround, so that the greatest effort to make span time improvements can be placed on those subsystems which have the greatest improvement potential.

NETWORK ANALYSIS MODEL (NAM) CONCEPT

In addition to the network representation already discussed, other inputs to NAM are the frequency and time span distributions for each activity. As noted in the illustration, the probability of occurrence is expressed in terms of a total and a critical part with frequency and time distributions for each. These inputs may be obtained as direct outputs from SSM. In the operational phase of a weapon system, the required inputs for NAM may be collected from operational data.
The computational procedure used in NAM is a straightforward application of Monte Carlo Simulation whereby sufficient simulations are made to obtain a statistical distribution of the outcomes. In the case of each iteration, random draws are made to determine the occurrence in the time span of each activity. The next step is to compute the longest path through the network, a step which corresponds to tracing the critical path in PERT. As in PERT, the time span for the task is equal to the longest path. However, the longest path differs from iteration to iteration. On each iteration, statistics are collected concerning the occurrence of each activity on the longest path and concerning the contribution of each activity to the overall span time. The computational procedure is completed by a statistical analysis. Finally, the model outputs represent the distribution of task completion times and the contributions of each activity to the mean span time.

Although the primary application of the Network Analysis Model is the analysis of the impact of unscheduled maintenance on aircraft turn-around time, the model may also be applied to the analysis of any sequence of activities represented as a network. A special application is the use of NAM to obtain the sum, maximum, or the combinations of sums and maximums of a series of probability distributions, which are often necessary in weapon system studies. Frequently this is very difficult to do by analytic methods without imposing restrictions on the form of these distributions. The Network Analysis Model imposes no restrictions on the form of these distributions.

**NAM RESULTS**

The outputs of the Network Analysis Model and two principal uses of these outputs are illustrated in the chart. In this example, the network that is being considered consists of 20 activities and represents the unscheduled maintenance
activities associated with an aircraft turnaround. Eighteen of the activities (2 through 19) are associated with the maintenance on major subsystems; the activities numbered 1 and 20 are dummy activities and correspond to the start and end events in a PERT network. The computer outputs of 400 simulated turnarounds are shown. The number of times on the critical path, the total time on the critical path, and the average time on the critical path are given for each activity as well as the mean span time for the turnarounds. From this analysis, the subsystems can be ranked according to their contribution to this mean span time. In this example, the mean span time is 3.646 hours and subsystems 3 and 18 contribute around 30 percent of the overall maintenance span time.

In addition to the mean or average span time for aircraft turnaround, the probability distribution of turnaround time is important in availability analysis. The model provides outputs so that this distribution can be plotted directly as shown. The number of data points for this output are controlled by an input; instead of 10 data points, the model could provide 20, 40, or 100 as desired. The only restriction is that the number of data points be a divisor of the number of simulated runs.

NAM is programmed in a special purpose programming language known as SIMSCRIPT. To handle a representative network of 22 activities, 500 iterations can be made in 1 minute of machine time; based on these 500 iterations, it is estimated that the computed mean is within 2 percent of the true mean.

LIST OF REFERENCES
THE
F-111A CREW MODULE

The crew module, an integrated part of the forward fuselage, is composed of a pressurized cockpit and the forward portion of the wing glove. The entire module is an emergency escape vehicle, and is considered as the ultimate concept in crew safety.

With this system, crew members are afforded maximum protection and safe escape throughout the aircraft's entire performance envelope. Required escape and protection features include a capability for zero altitude and zero speed ejection, an underwater escape capability with self-righting buoyancy and flotation, and post-ejection environmental crew protection against hazards on land or in water. Attenuation bags absorb landing impact.

Uniqueness of the F-111A’s crew module is enhanced still further with the “shirt sleeve” flying concept. Designed around this concept, the module’s environmental control system maintains normal pressurization at 8000 feet cabin altitude for all airplane altitudes of 8000 feet or above. An emergency oxygen supply and emergency cabin pressurization supply are furnished as part of the crew module system. Full pressure suit capability is provided if desired.

Two adjustable crew seats are located within the module. The crew seats—contoured for comfort—are positioned in a side-by-side arrangement. Providing adequate safety restraints, the seats utilize upper torso and lower torso harnesses with a five-point hookup. Freedom of movement and comfort is increased by eliminating the necessity for personal parachute and survival gear to be strapped to the crew member. Crew module survival and rescue aids consist of standard survival gear, devices for locating survivors, and other special equipment. All provisions are accessible from within the module.

CREW MODULE

Side-by-side crew arrangement is designed for safe, effective mission accomplishment. Crew members can work together more readily, aid one another with mission tasks, and still maintain the same forward visibility—an important factor in high-speed, low-level flights. The integration of controls and displays provides a compact arrangement which minimizes the need for duplication, backups, and standbys.

The left, or Aircraft Commander’s station, is the primary flight station. It is equipped with all necessary automatic and manual controls for flight and mission accomplishment. This includes instrument displays, aircraft systems controls and indicators, navigation aids, weapon release controls, and delivery displays.

The Pilot/System Operator’s station on the right is the primary avionics system control station. System controls, displays, and weapons delivery controls for mission accomplishment are equipped in this station. Additionally, the necessary flight controls and instrumentation are provided to enable the right seat crew member to perform pilot functions.

Within the crew station, test switches and control panels are conveniently located on readily accessible consoles. Provisions for storage receptacles for maps, charts, liquid, food and relief containers have been made in each station. All are easily accessible for in-flight utilization. Fully adjustable seats enhance crew comfort and cockpit operations. Pressurized and temperature-controlled air provide a comfortable environment.

PRESSURIZATION SYSTEM

The “shirt sleeve” flying environment of the F-111A’s crew module is attained with an intricate pressurization system. This system provides both normal and emergency pressurization.

Normal pressurization is maintained at 8000 feet cabin altitude for all airplane altitudes at or above 8000 feet. A caution light, which illuminates at 10 psia (10,000 feet) cabin pressure, and a warning light, which is activated at 3 psia (38,000 feet), assist the crew in determining cabin pressures.

If normal module pressurization is lost at an altitude exceeding 5 psia (27,000 feet), the emergency pressurization may be manually activated. In turn, the aneroid operated pressure regulator will reduce and regulate the air supply to main-
tain the module altitude between 5 psia (27,000 feet) and 5.7 psia (24,000 feet).

Upon ejection of the module, emergency pressurization is automatically actuated. An emergency pressurization bottle, containing 650 cubic inches of breathable air at 3,000 psig, is capable of maintaining a module pressure of 5 psia at design crew module leakage for two minutes plus free fall from maximum altitude or for fly down. The canopy pressure seals, normally supplied by engine bleed air, are supplied from the emergency pressurization bottle.

**EJECTION SEQUENCE**

Optimum crew safety and escape features of the F111A's crew module are highlighted with a high performance ejection system and stabilization capability.

Crew module ejection can be initiated from either the right or left station. The ejection sequence is actuated by pulling either of two "squeeze and pull" type handles, located between the seats on the center console. After actuation, all succeeding functions through landing are automatically performed by means of an explosive train. Pulling either handle will explosively activate the inertia-lock rears retracting both upper torso harnesses in the crew seats, actuate the emergency oxygen and cabin pressurization system, activate the chaff dispenser, cut primary structure and secondary controls, ignite the explosive severance system, rocket-thrust the crew module from fuselage, deploy the stabilization-brake parachute as well as the recovery parachute, and activate the impact attenuation system. Manual backups are provided for the emergency oxygen and pressurization system, as well as for the recovery parachute deployment.
LOGISTIC PROJECTS

In a complex industrial structure—like the aircraft design, manufacturing, and support business at General Dynamics’ Fort Worth Division—there is a need for functionally oriented departments which can provide direct assistance to Management. Typifying this situation is the 111 Logistic Support Department. Subdivided into departmental sections, each one has a Chief who reports to and works closely with the Department Manager. Within these sections there is one, Logistic Projects, oriented to all phases of 111 logistic support. This coterie serves as a second "right arm" to the Manager.

Located in a planning-direction-coordination type atmosphere, the section’s aim is to obtain, develop, and maintain a group of knowledgeable project-type personnel who are capable of working in all areas of logistics. They, in turn, coordinate and assist the efforts of all sections of the support department and other departments to assure that logistic support programs are properly planned and documented as required.

In general, Logistic Projects confirms the implementing of logistic plans and contractual requirements, and analyzes currently used procedures in an effort to continuously increase the department’s efficiency. Logistic project analyses are coordinated, evaluated, and compiled complete with detailed recommended solutions and methods of implementation of logistic support areas identified by Management.

The roster of work activities also includes preparing formal 111 logistic support presentations for industry and military use; assigning qualified logistic engineers to each program for a single point of complete program knowledge within the department; and accomplishing logistic planning and proposals for competitive bids for new weapon systems, products and services.

Project Engineering and Project Services—the two subsections of Logistic Projects—serve to accomplish the supportability tasks.

Project Engineering is the prime consultant to logistic management on support projects. This group directs preparation of the logistic portions of Division Proposals for new and existing programs—developing and reviewing specifications for logistic compatibility, supplying logistic ground rules, and comprehensively studying weapon system logistic requirements of each model aircraft.

Among other significant functions, Project Engineering produces logistic requirement documents for vendors/subcontractors, evaluates subcontractor proposals in logistic areas, and conducts contractor coordination in general. Representation of logistics in interdepartmental meetings is necessary in cases like engineering program proposals, contract conferences, and weapon system program planning.

To maintain an intimate knowledge of each model of the weapon system—such that all areas of logistic support remain under surveillance—constant analyses are made of support areas. Subsequently, Management is advised, and methods of improvement and refinement can be established.

Project Services embraces the areas of Air Force Depot and Naval Air Rework Facility Programs, Program Change Reviews, Customer Services, and Other Services. The depot programs entail developing plans and providing contractor assistance—going beyond the intermediate maintenance level—for both Air Force and Navy.

Inherent in the Program Change Review function is reviewing program and design changes to determine their impact on the total logistic task. Controlling the departmental reviews of all Engineering Change Proposals (ECPs) is a vital aspect of this work. ECP status and a consolidated departmental position are established on each change.

Customer Services covers the developing, preparing, and arranging for logistic studies, presentations, or other information requested by the Government or directed by Management. Other Services essentially consists of performing special assignments for the Manager, such as acting as his alternate in activities connected with the Product Support Committee of the Aerospace Industries Association and serving as the alternate General Dynamics Representative on the F-111B Integrated Logistic Support Management Team. Creating and distributing informative periodicals like the 111 LOG is an additional responsibility.

Through these means the Logistic Projects Section provides direct and indirect assistance to the Manager in his effort to centrally control and coordinate those functions which transcend the functions of the remaining logistic sections.
MOTION PICTURES AS A MEANS OF TRAINING
Motion pictures found a voice in 1927. Now in addition to a mind which investigates the nature of man and his ideas, motion pictures also explore the nature of space and spatial achievements. At General Dynamics’ Fort Worth Division, cinema artists specialize in making movies with a message as well as with a mind and voice.

With a professional staff of four cameramen, three film editors, two scriptwriters and directors, one animation and effects specialist, a librarian, and a secretary, the Office Services Department Motion Pictures Section proceeds full-speed ahead, producing an average of ten sound-color films a year. Currently all of the films being made serve as orientation to the F-111 Program. These movies are shown to internal top management personnel, the Using Commands, Corporation field offices, congressmen, Pentagon officials, and various service organizations for taxpayers’ information.

Two divisions of films are made: documentary and photo flight test. These motion pictures play important roles in Logistic Training, a branch function of Logistic Support.

Documentaries—or sequential progress reports—are required contractually by the United States Air Force. Usually 16 release prints are made for distribution, and the USAF permanently retains eight of these prints. The remaining prints are used for staff orientation training that is requested by the customer and for special requests from customers to accommodate necessary briefings due to the rotation of military personnel.

The Tactical Air Command’s combat crew training program at Nellis Air Force Base in Las Vegas, Nevada, is responsible for training pilots who will fly the modern-day fighter aircraft. F-111 flight training films are most valuable to crew training students and instructors.

Photo flight test films have been featured also at places like Cannon AFB in Clovis, New Mexico, for the air crew training detachment unit of the Air Training Command. Showing the F-111 weapon system, these motion pictures are used by the ATC air crew instructors and focus on such systems as terrain-following radar, low level altitude work, radar fire control, and spin tests.
MOTION PICTURE MARKET

Motion pictures have become an important means of training for customers. Since Technical Representatives are responsible for indoctrination programs on 111 weapon systems, technical information, feasibility studies, and presentation aids for customers, the motion picture function at Fort Worth Division has gained in prominence and stature.

An ace form of sight and sound communication between Contractor-Customer, films have enriched various interests in the F-111 Program. Cinematic contributions to customer and personnel training have greatly improved the close coordination of all logistic elements with applicable Government agencies.

Making professional films requires a high degree of perfection. Through group effort, efficiency, talents, fine equipment, and combined backgrounds of experience, movie-makers are able to mix art and science into a meaningful, informative whole. Using top quality motion pictures, then, is an integral and important part of the Logistic Training Program.

In meeting contractual requirements, training films must be informative and timely rather than entertaining. Although there are no screen sirens or other box office champions—in fact, there are no offices at all—there is quite a demand for films featuring the F-111. So, while producing "blockbusters" is irrelevant, and industry Oscars are nonexistent, movie audiences for training films still expect top-notch motion pictures.

IDEA IGNITED

When did Fort Worth Division's dynamic "celluloid world" begin? Its genesis was an idea spawned over 14 years ago, in the Spring of 1953.

The proposal was made to the Air Force, based on the fact that since the Contractor of the B-58 aircraft was closer to the project than the USAF, the Contractor could make progress report films on a more timely basis. Air Force officials liked this notion, since they had been making their own films, which were often outdated by the time they were ready for release.

After the proposal to install motion picture facilities in the Fort Worth production plant was approved by the Systems Program Office (SPO), the internal unit was created. Outside contractors helped at first, since film-producing facilities were nil. In fact, individual film frames had to be screened by hand and by eye across a desktop, using a white paper background and a pencil to roll the film on a borrowed reel.

By contrast, a tour of today's motion picture-making facilities reveals a major reason film operations have become so successful.

FILM FACILITIES

Located in the main plant, the entire setup is architecturally designed for work, concentration, and privacy. In essence, the "studio" is a building within a building, in that the walls and roof surrounding the motion pictures operations are double-double thick.

Motion Pictures is labeled a "Closed Area." Thus, the strictest rules of Security are enforced. Numerous electronic private eyes, or motion detection devices, have been installed to protect the area from unauthorized intruders. In addition, there are "Authorized Personnel Only" signs throughout the section.

Upon entering the front door to Motion Pictures, you get an immediate impression that good organization is the keynote to all activity. Leading off the office area is the ANIMATION ROOM. Here the Oxberry camera—with extensive zoom, pan, tilt, and rotation capabilities—shoots animation of operations that cannot be photographed "live" by a camera. It also films titles for all productions.

The first in a series of corridor doors opens to a SUPPLY ROOM, which serves as a packaging facility for films and other mail-outs. Next is a UTILITY ROOM, housing the timesaving, eyesaving edge-numbering machine which prints sequential numbers on every foot of film. Before this machine was purchased, film editors had to look for specific frames by matching roads from 50,000 feet. Scene lagging is the primary work done in the Utility Room.
The FILM LIBRARY houses four kinds of film: release film, in-work film, stock film (unedited master footage of particular scenes), and preprint material on completed release films (from which new prints can be made, if necessary). Two annex rooms flank the Film Library—the VAULT and the LIBRARY WORK ROOM. The Vault contains "raw stock"—fresh film. The constant cool temperature here prolongs the life of film. The Library and Vault files are managed by three film librarians, one who works full-time and two who also double in other film work.

The other adjoining area is the Library Work Room, which is used for previewing films before they are checked out on loan. Screening is achieved by a dandy color TV-like apparatus called a Moviola. With the film running beneath the miniature movie screen, previewers can control the film—speed it up or slow it down—with the flip of the dial.

This room also houses a power rewind machine, a portable hot splicer, and lots of color-coded spools of celluloid (which are used on the head and tail of each release reel of film). Film identification is always written on the head of the release print on blue celluloid; the tail of the film is always yellow celluloid. Other plastic leaders are color-coded red for original, green for masters, and white for prints.

The EDITORIAL SUPPLY ROOM is self-explanatory. Three different FILM EDITING ROOMS are equipped with Moviolas, viewers, rewinds, etcetera—all the tools of the film editor’s trade.

Approaching the SCREENING ROOM there are chalkboards and film project scheduling charts along the corridor walls. The Screening Room—used as a workroom for previewing work prints by the motion picture people—can seat fifteen.
It is also scheduled by small groups for viewing progress reports and special test footage.

The CAMERA ROOM has a total darkness capacity, since cameras must be loaded "by braille." There are various movie cameras for documentary filming, with the Arriflex being the basic 16mm camera. Although there is equipment for making 35mm film, there are few requirements for it.

Additional equipment includes a quarter of a million watts of light available in lighting equipment, an assortment of lenses and accessories, clamp-ons for quartz lights used in set lighting, tripods, dollies, camera cleaning facilities, and other necessities. A strange-shaped black box called a Blimp is used while filming sync sound. The camera fits snugly inside the Blimp, which is padded to eliminate camera noise.

Triple-duty adjoining areas are provided for projection and sound. The SOUND BOOTH, surrounded by a special 14-inch thick wall, has no right angles in the entire room. Thus, the "bounce" of sound is completely eliminated. The SOUND ROOM is where sound -- narration, sound effects, and music -- recorded on quarter-inch magnetic tape is adroitly transferred to 16mm edge track and later synchronized and edited with the picture. Adjacent to this area is the Mixing Console which has dials and switches to control three dubbers, a recorder, a projector, and a footage counter. The twist of one big, black knob turns everything on in unison for final film presentation in the INTERLOCK THEATER.

The Interlock Theater, at the rear of the "film factory," is acoustically designed to omit the bounce of undesirable sound. This is where Top Management, seated in some 20 canvas director's chairs, comes to critique films on a big screen prior to their release. These Interlock cinema viewers serve as an approval board for all films.

The theater's name, Interlock, was not an accident, for all mechanisms must be interlocked for motion picture showings. Even though the sounds and motion picture are still in separate pieces, everything runs "in sync" -- giving the effect of a finished film. Entrance to the Screening Room and Interlock Theater involves an intercommunication system with the secretary before access to the Closed Area is permitted.
Three sets of giant double-doors are adjacent to the Interlock Theater. The outer twin doors weigh 350 pounds, and each of the middle and inner sets of solid core doors weighs 300 pounds. The doors serve as an entranceway for large pieces of cinematographic equipment.

**MOVIE-MAKING PROCESS**

First-rate film facilities are vital to successful movie-making. But good procedures in the actual composition of a motion picture are just as essential. The step-by-step process of making a 20 or 22 minute-long movie begins with the contractual assignment from the SPO and the gathering of basic information. Current progress report filmscripts are dictated by activity of the F-111 Program; final scripts cannot be written until after the film is shot. Training films are pre-scripted and shot to the script.

The writer-director goes "on location" with the cameraman. The preloaded camera(s) is readied for shooting, accessory equipment is set up, and the scene is lit. Electrical support comes from the Maintenance Department, whose crew members also handle the lighting. Then come the famous words: Lights! Camera! Action! And the camera(s) records activity.

The writer-director covers events in such a manner that they can be edited into meaningful sequences. Thus, a variety of long shots, medium shots, close-ups, cut-ins, and cut-aways are made. After film is developed in Dallas laboratories, it is returned to the Film Library.

Scenes are then logged and reviewed by the cameraman, three editors, and two scriptwriters. A "work print" is given to one of the film editors, and the script narration is written. As the writer writes, he works closely with technical personnel to certify his information as being technically correct.

The narrative script must be approved by Management, Security, and the local Air Force before being sent to F-111 SPO Top Management officials. Upon their concurrence, the narration is scheduled for recording. A professional narrator, under contract to the Division, is called in, and the sound track is recorded. (The script is always printed on nonrattle paper.)

The sound track is transferred from quarter-inch magnetic tape to 16mm film before the editing process begins in earnest. Film and sound track are worked together. Also, a "bias" track of room sound is made which can be spliced between narration and sound effects. The bias prevents any portion of the film sound from being absolutely silent, or "dead." Narration is added, and the film title is shot.

After music selection for the head and tail of the film, the motion picture is ready for Top Management screening, or Interlock approval. When all of the work print is in a state of finished film, original full scene lengths that match work print scenes are pulled by edge number. Then they are sent to the lab to make masters, since original film cannot be cut and spliced. The "conforming" stage, whereby masters are made into "A and B" rolls in preparation for printing release prints, comes next.

Then, the "whole bit" goes to the West Coast lab for printing, and the mix-mag track is transferred to an optical track for printing. A release print is the finished product. Usually 16 release prints of contractual films are made, while as many as 60 prints of special films have been made on occasion. Release prints are always checked before leaving the Film Library for presentation.

**FILMS IN FOCUS**

The human brain is a billion lens motion picture camera, shooting and coordinating billions of frames a second. It has been said that the "imprint" system is one of these frames — stopped — upon which man's perception and symbolic thinking develops. What happens inside or outside, we perceive in terms of our mental imprinting system.

By comparison it is interesting to note that it takes an average of 126 man-hours to put one minute of finished film on the screen. A motion picture style cannot be created without having the people involved make both business and creative decisions. Thus, the art and craft of this celluloid citadel are wedded. Crew members — who learn from each other, yet remain individual innovators — contend that they have as good a crew as you could find anywhere in an industrial plant. They take much pride in their work.

Motion pictures as a means of training now plays a significant part in the Corporation culture. The genre of films pioneered over 14 years ago — carefully cultivated and maintained — has reached such arête, or excellence, that today's motion pictures are like Tritons among minnows.
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