Convair—San Diego Is Host to March Simulation Council Meeting

It was an unusual pleasure to experience Stan Roger's well-organized handling of the Convair meeting on the afternoon of 19 March in San Diego.

When we arrived, Stan had our new Simulation Council badges, which had been printed up for the occasion. Most of them were filled out in advance with our names (correctly spelled) and affiliations in large legible type. Those not already prepared were quickly typed out by Stan's attractive secretary (one of us wanted two badges) on a "jumbo" typewriter furnished by the San Diego Convention Bureau. Even "Security" was on the ball — as far as I know everyone got in all right; at least 50 of us did, for that was the count at the meeting. They even let us take in our (that is, Uncle Sugar's) tape recorder when we agreed to leave the tape to be properly cleared after the meeting.

Mr. C. B. McCabe, Convair's Chief Engineer, welcomed us. Then Stan introduced H. C. Roderick of Convair's Dynamics Group, who told about some of the difficulties encountered in actually setting up a large-scale simulation. The project was classified, so we can't give details but only a general idea of the subject matter of Mr. Roderick's talk.

An analog computer was used to simulate the motions of an airplane as the result of control surface deflections, while a standard hydraulic test stand some distance away was used to control the "flight" of the simulated plane. Feedback was used to give the stick the proper feel, and the cockpit was equipped with a throttle, and the usual airplane instruments were actuated by the computer. Because of the human pilot in the system, if for no other reason, the simulation was made in real time.

In its initial form all nonlinearities were removed from the simulation, velocity and altitude were held constant, and solutions were found to check with hand solutions.
Subsequently servo and electronic multipliers were added one at a time and the effect on the solution noted. As more and more multipliers were added damping became poorer, nonlinearities appeared, and solutions were not repeatable. Investigation indicated that the original estimates of the amplitude of airplane variables resulted in voltages sufficiently low to be affected by the noise and the inaccuracy of the multipliers. Changing scale factors to increase the voltage levels eliminated 80% of this type of trouble.

Roderick said the only difficulty traceable to the long trunk lines to their console was a 150v 1200c oscillation of a GEDA amplifier. This was eliminated by choosing staggered trunks.

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The value of simulation as a tool for design and development is generally understood. Its value as a tool for subsequent evaluation of systems and components is not so widely recognized. LeRoy Day, the next speaker, told of setting up a rather complex simulation at NADC which has made valuable contributions to the evaluation of a missile system.

When used for evaluation in conjunction with a test program, Roy pointed out that simulation can accomplish the following:

1. Determine the "sensitive" parameters and thus aid materially in planning an efficient test program.

2. Extrapolate test results to unobtainable or uneconomical test conditions.

3. Investigate problems of a statistical nature, i.e., the effects of noise, miss distance, etc.

4. Establish probable cause from measured test results.

Again it is not possible to give details, but the scope of the simulation may be of interest. The problem Roy described was setting up a two-dimensional simulation of a launch aircraft, a missile, and a target. Both missile slowdown and lateral acceleration were functions of two nonlinear variables, speed and wing deflection. The speed of both the launch airplane and the target were held constant, but in some cases the target was allowed to turn.

Some of the most interesting work Roy described resulted from their finding early in the simulation that the noise characteristics of the launcher pilot tracking error had a profound effect on the miss distance.

The reduction of photographic data to produce records of the actual pilot tracking noise, and the subsequent introduction of this noise into the simulation created problems which Roy discussed.

Instead of introducing measured noise, for statistical reasons it was decided to build a random noise generator. This of course raised many more questions and a few real problems. The solutions Roy described must have been adequate, however, for they got good correlation with flight tests. The slowdown, being a function of many other variables, is considered a key parameter. It was checked by getting the same time of intercept in simulation as in the corresponding flight. Two-dimensional trajectories were also duplicated, first in azimuth and then in elevation, yielding in effect a three-dimensional check. When components of an actual missile were used to replace the corresponding simulated components, the recorded outputs of the real and simulated components were almost identical.
Noise at Hughes

The meeting at Hughes to discuss noise, which we mentioned in our last Newsletter, was held as planned on 10 March. (The meeting was held, that is — the noise was more difficult to grasp). R. R. Favreau (Hughes Aircraft) did such an excellent job of explaining and leading the discussion that your Editor left the meeting with the feeling that for the first time he knew something about noise. However, your Secretary did such a thorough job of taking notes (14 typed pages!) that when the Editor read them over he was confused again.* So he asked Bob Buland, the Naval Air Missile Test Center's noise boy, for help. Boiling Suzy's notes down and seasoning to our own taste, we offer the following story of Noise at a Hughes Meeting.

While waiting for everyone to arrive, Stan Rogers (Convair) brought up the subject of the Statistical Instrument Company's Ultra Low-Frequency Noise Generator.** Favreau said that he knew nothing about it except what was in their brochure (a copy of which your Secretary produced and passed around) and this failed to mention two things — the noise and the stability. He said Hughes found it necessary to put a regulating circuit in their generator.*** Because it takes hours to measure spectral density it is imperative that the generator be free from drift or you'll be putting into the system something different from what you think you are.

Favreau added that this was not a sales pitch for the Hughes noise generator — that unless and until there is a change in policy, Hughes will not make any noise generators except those which they already have orders for.

The Goodyear noise generator (discussed in the November Newsletter and C. H. Reynolds' letter in the Newsletter of last month) was also mentioned, and this started a premature discussion of parameters which John Mandrow (Hughes) said were the basic question of the afternoon. In dealing with noise and noise generators, what parameters must be specified?

McLeod (NAWTC) wanted to know how to distinguish between drift and very low-frequency noise, but didn't get his answer till later.

About a dozen people had arrived by now, so Favreau (with frequent "assists" by Mandrow) began his discussion of random noise, power spectrum, probability distribution, "white" noise, Gaussian noise, Rayleigh noise, drift, mean, non-stationary noise, autocorrelation, Fourier analyses, standard deviation, and other such things. At one point Favreau mentioned a sine wave having zero width, infinite height, and unit area. Schart (Convair, San Diego) protested that this was "profanity!"

*I once had a professor who claimed "It is not so much that the subject is confusing as it is that some people are so easily confused!"

**Statistical Instrument Company, Box 552, 90 Church Street, New York 7, N.Y.

***Described in detail in D. E. Beccher, R. R. Bennett, and H. Low's paper "Electronically Stabilized Noise Generator" available from Hughes Aircraft Company, Culver City, California
Briefly, (perhaps too briefly) this is what your Editor got out of the discussion (I think).

Noise is a random variation of a quantity. Because it is random it is not possible to predict its value at any future instant. However, noise can be completely specified by two characteristics - its power spectrum, and its probability distribution.

The power spectrum is determined by plotting the power per cycle at all frequencies against the frequency.

The probability distribution is determined by sampling and plotting the frequency of occurrence of amplitudes against those amplitudes.

If the power spectrum is flat out to a given frequency, the noise is said to be "white" to that frequency. It is advantageous to use white noise in system studies because there is equal power in all frequencies up to the specified minimum.

One of the most common probability curves found in practice is Gaussian, or normal. This is fortunate because there are well-developed mathematical techniques for handling such a distribution. Then there is the Rayleigh distribution, but I don't know why.

The probability distribution may have any form. If the center of gravity of the form is displaced from zero, the distribution is said to have a mean. A Gaussian or other distribution might have a mean. A Gaussian distribution is completely specified by the mean and the standard deviation. Noise generators with drift will introduce a varying mean which is difficult to measure, and will produce a peak near zero in the power spectrum.

Noise having a probability distribution which changes with time is said to be non-stationary noise.

Autocorrelation and Fourier analysis are used in the determination of the power spectrum of noise.

If the system under investigation is linear, there are better methods of analysis than the use of a noise generator. However, most systems are not linear and this makes it difficult or impossible to predict the effect of noise on the output. It is then that the technique of introducing generated noise into the simulated system really pays off. But the generator must be calibrated and stable or you won't know what you've got!

Favreau then described the Hughes noise generator. It has a frequency spectrum which is "white" from zero to 35 cps, which they feel more than covers the range useful for the majority of simulator applications. The probability distribution of the output is Gaussian, which is the desired distribution for most uses.

One of the features of this noise generator which probably make it unique is the method of discarding the low frequencies where the gas tube, which is the primary noise source, is unstable, then shifting the spectrum back to zero by subsequent "detection"; another feature is the regulation to prevent drift.
Some WADC Experience

In line with our endeavor to keep our readers informed of what goes on at facilities we cannot visit, we take pleasure in passing on to you some interesting information received from L. H. Warshawsky of the Wright Air Development Center Aeronautical Research Laboratory, Wright-Patterson Air Force Base, Ohio. Here is his complete letter:

In the past few weeks whenever a few minutes were available I’ve been reading through your Newsletters starting from the December 1953 issue and working backwards. I’ve gotten to the March 1953 issue and I figured it is about time I sat down and wrote you a letter, first to inform you of our existence and secondly to present our slant on a few of the subjects you fellows have been kicking around.

Here at WADC there are several simulation groups. Captain Jack Sides’ outfit is one of them and concerns itself mainly with autopilot airplane marriages. Major Dick Lathrop has another organization located in the Flight Test and All-Weather Directorate which busies itself mainly with automatic landing systems for aircraft. Then there is our group known as the Computation Branch of Aeronautical Research Laboratory which is the largest of them all and handles just about every type of problem as a service group to the laboratories of WADC as well as to their contractors (under certain conditions). As our tools we have an analog section consisting of four Reeves Q101s, four S101s, two GEDA L3s and two GEDA N3s (some of the GEDA equipment is not yet delivered) several plotting boards, function generators and other accessory equipment. We have two digital computer sections, one using the ORAC, a general purpose large scale, medium speed, computer built by G.E., the other using three IBM CPCs which will be replaced soon by a Remington Rand Model 1103 or its equivalent.

My personal connection is with the Analog Section which has been doing business for five years and has turned out reams of work in problems involving almost every scientific and engineering field. Most of our problems are of the type that run for two or three weeks and involve two, three, or four REACs. At the end of that time, a new, entirely different, type of problem is tackled. I am sure that at no other installation of this type with the possible exception of Goodyear’s laboratory in Akron, is such a variety of work handled. I mention this because a layman reading your Newsletters might get the impression that this analog equipment is only suitable for investigating missile guidance and control systems and determining miss distances. We do our share of that type of work too.

We have not to this date made too much use of the proximity of our digital groups in checking our solutions, mainly because of the comparatively rapid fire method of handling problems on our analog equipment. Well before they could code and run a check case, we have completed five hundred parametric variation runs on the problem, and are two problems ahead of them. Maybe when we get the super large computer (about 500 operational amplifiers) that is slated for us, and work on some problems that will utilize something near this full capacity, we will be slowed down sufficiently for them to do us some good.
We have been giving serious consideration to the procurement of some digital differential analyzer equipment to use for checking our analog solutions. To this end we sent a rather nasty typical problem that we had solved on our REAC to both CRC and Bendix to see whether it could be coded for their machines and how much equipment would be required. We have not reached a decision yet as to the feasibility of this check procedure. Oh yes — both CRC and Bendix successfully coded the problem.

Along this same line it happened quite recently that we did have a check made on our OARAC of a rather simple trajectory problem involving a parachute decelerated bomb. This problem had been solved on the REAC about six months before, and to aid us in reaching a decision as to the feasibility of using digital differential analyzer equipment as a checking method, we turned it over to Major Lathrop's All-Weather group, which possesses two original Northrop Maddidas. They solved the problem and presented us with tabulated results as well as graphical. When the tabulated values were plotted on the curves yielded by the REAC, serious discrepancies of the order of 5% were noted. Grasping at straws, I next asked our OARAC group to solve the problem. To our surprise (and I wouldn't be telling you this otherwise) the OARAC results checked the REAC trajectory about as close as could be seen on the rather large plots we had. The only exception was in one curve wherein velocity of the bomb was plotted versus time. In this case a discrepancy of some magnitude was noted near the end of the curve, and the error was obviously in the OARAC solution. After several tries the OARAC finally yielded a solution for this quantity which checked the REAC within about 0.2%! It might interest you to know that the reason given by the OARAC people for the obvious error was that too short a computing interval was being used resulting in a pileup of roundoff errors. In fairness to the OARAC it should be stated that they took advantage of the existence of the REAC solutions and did not provide the usual number of automatic checks which would have caught the errors. I was sure living for a couple of days!

I see this letter has become too long so I had better sign off. However, I would like to add my congratulations to you and the missus for a job well done in getting the Newsletter out.

Yours sincerely,

L. H. WARSHANSKY
Project Scientist, Computation Branch
Aeronautical Research Laboratory
Directorate of Research

Because your Editor has had limited experience with digital check solutions, we asked Lieutenant Commander J. C. Aller, formerly in charge of the RAYDAC and now acting head of the Guidance Division, Naval Air Missile Test Center, Point Mugu (my boss) to comment on the letter. Jim concurred in general, but added:
I should like to point out that where internally programmed machines of medium to fast speed are available, development of the techniques of interpretive coding permit fast coding (less than 2 weeks) of digital check solutions. Experience with use of CPCs for this purpose is misleading since in general the application of interpretive coding techniques is possible only with internally programmed digital machines.

If complete duplication of entire analog computations is desired, check solutions computed using interpretive techniques probably are too inefficient and the more time-consuming methods of coding would be required.

"Midwestern Simulation Council"?

A letter tells us of the pending formation of a "Midwestern Simulation Council". We hope to be able to give you the details before long. How about our friends in the East? Certainly there are enough of you!

"Process Control Council"?

We are going to a meeting on 13 March with Jack Walker and others interested in the formation of the "Process Control Council" we were talking up in the last Newsletter. We hope to be able to give you the details on that project before long also.

Association for Computing Machinery Offers Opportunity

We are in receipt of a letter from Dr. Walter F. Bauer of Willow Run Research Center, Ypsilanti, Michigan, which reads in part:

Dear Mr. McLeod:

As you may know, the annual meeting of the Association for Computing Machinery will be held at the University of Michigan in Ann Arbor on June 23, 24, and 25. It is the hope of the program committee that a wider selection of papers on analog computation will be presented at the meeting than in the past.

It seems that a wealth of interesting technical papers on analog computations might be found among the members of the Simulation Council in southern California. Present plans, still tentative, call for two invited papers to be given on real-time simulation, one on analog methods, and one by Dr. M. Rubinoff of the University of Pennsylvania on digital methods. Along with these two invited talks, we hope to have a number of 20-minute papers.

If you or any of your associates feel that you can contribute to these sessions with 20-minute papers, please submit abstracts not longer than 120 words to me by April 15.

I would appreciate very much your including a note in the Simulation Council publication on the meeting and the general plan for sessions on analog computation.
This puts it squarely up to us. Some of us in the past have felt that the analog people were being ignored. But Dr. Ridenour invited our participation on the West Coast, and now this letter. If we have anything to say, let's say it! Don't let the April 15th deadline stop you. Chances are no worth-while analog paper will be turned down if it is only a little late. Besides if some of the rest of you don't get on the ball your Editor might be the sole speaker for analogs. "Brother! Come over the bridge!"

American Rocket Society

We also have a letter from Noah S. Davis, Jr., Chairman, Program Committee, American Rocket Society (Buffalo Electro-Chemical Company, Inc., Station "B", Buffalo 7, New York, which reads in part as follows:

Gentlemen:

This is written to invite the participation of members of your organization in the technical sessions of the American Rocket Society's Fall Meeting. This meeting is tentatively planned for on or about the first of September and may take place at White Sands Proving Ground, Las Cruces, New Mexico. We are awaiting official government approval.

The theme for this meeting is "missile testing". We feel that you are well qualified in this field and we are hoping that perhaps some members of your staff may have suitable papers for presentation at this meeting or another meeting of the A. R. S. (We have one meeting planned in Pittsburgh, Penna. from June 20-24 1954, and our Annual Meeting in New York in December 1954.) The American Rocket Society's membership has grown to approximately 3000, the majority of whom are actively engaged in the rocket and jet propulsion fields. The American Rocket Society is an affiliate of the American Society of Mechanical Engineers.

Unfortunately the requested date for notification of intention to participate has already passed, but good papers are probably still acceptable.

Simulation Council May Meet at Hughes

Lest someone take our pun seriously, we rephrase: Simulation Council will meet at Hughes Aircraft in May. The date and other details will be given in our April Newsletter, which we promise you we will get to you in time to make the May meeting!

Subscriptions to the Newsletter

To subscribe to the Simulation Council Newsletter, send a check for $6.00 to the Simulation Council, Box 731, Camarillo, California. The six bucks cover the cost of a one-year subscription.