safely up the 4-piece centerline assembly to the dual ring and thence around the base of the packed balloon on three extension lines, spaced 120 deg apart and connected to the drogue parachute.

The above interface design effort proved to be highly successful. Three other vital system design changes were also accomplished and qualified by flight test in the same period: One was the addition of a 5-ft ribless-guide-surface (RGS) parachute, to prevent recoil in the 200-ft extraction line as the module is pulled out of the C-130 by the system's 28-ft ring slot drogue parachute. This change was in response to an incident which marred the final Phase I test. The second change was the incorporation of an electrically fired 4-point pyrotechnic release subsystem, which drops the module away after balloon inflation. As the final major change, a sophisticated command, control, and telemetry (CCT) subsystem was developed for precise control and monitoring of the inflation process and the subsequent balloon flight.

Human factors were not neglected during the ALBS Phase II redesign effort. For example, the long module is best extracted from the aft edge of the C-130 ramp. This requires potentially hazardous in-flight movement of the module. A technique was developed, therefore, where the module is secured to and launched from a large pallet. This pallet, which stays in the aircraft, is locked to the C-130 side rails and can safely be winched forward and aft in flight. In addition, provisions were made for venting the helium boil-off vapors overboard when the system was being flown on the launch aircraft, and "system start" switches were designed to be activated only upon extraction of the module from the aircraft.

Full-Scale Flight Tests

On March 17, 1981, the assembled module was dropped over the White Sands Missile Range. All components functioned very well and balloon inflation was initiated; however, early in the filling process the balloon's internal inflation tubing ruptured near the base, causing a double bubble. The double bubble led to a bunching of the reefing sleeve and the balloon was torn open by excessive pressure. The test was quickly terminated and all components were recovered safely. The reason for the failure was clear and correctable and a repeat test was planned, using the one remaining ALBS balloon. The extruded polyethylene internal inflation tube of that balloon was replaced by one made of the same material used for the external tubing.

The second air drop was conducted on Sept. 1, 1981. All steps occurred as scheduled. The new inflation tubing inside the balloon easily handled peak gas pressures and a large bubble developed in the balloon (see Fig. 2). Then, about halfway through the inflation cycle, the balloon suddenly tore away. The test was terminated and all systems descended safely.

Films of the test showed that the inflating balloon was subjected to considerable buffeting (peak dynamic pressure was 1.4 psf). The balloon material may have been overstressed locally by peak transient loads; however, a more likely cause of failure was the rough edges found (after the test) along the periphery of the balloon's base casting, instead of the specified smooth radii. It is believed that the buffeting caused the stressed film to move back and forth across the roughness points, weakening it and initiating the failure.

Conclusions

Phase II of the ALBS Development Program showed that the air-launching of large balloons is feasible and can be executed routinely from standard Air Force cargo aircraft. Midair inflation of the balloon from a cryogenic source and recovery of the inflation hardware were also demonstrated successfully. Even though a structural weakness in the balloon prevented realization of the program's final objective of a successful flight following the midair inflation, that goal is not unattainable since the balloon weakness is correctable.

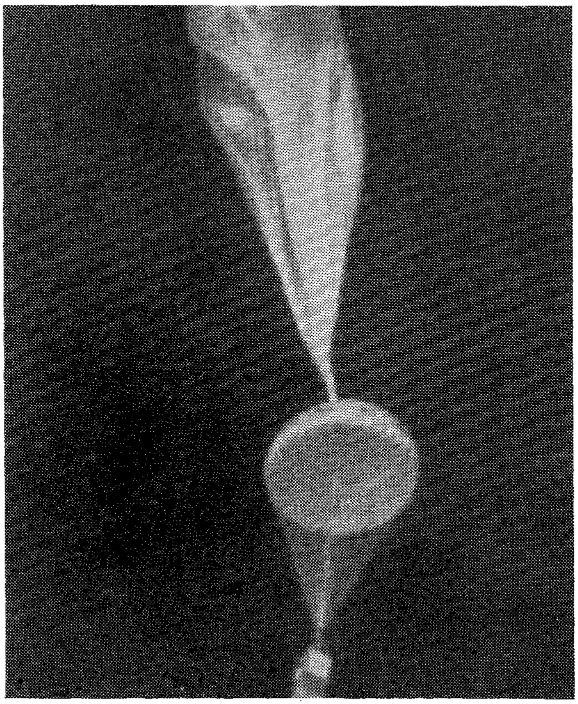

Fig. 2 ALBS balloon midair inflation, Sept. 1, 1981.

Acknowledgments

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AIAA 82-4201

Estimation of the Peak Count of Actively Controlled Aircraft

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Introduction

THIS Note summarizes an FAA-supported program to estimate the instantaneous air count (IAC) of actively

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controlled aircraft over the continental United States, for the purpose of estimating the size of replacements for the enroute computers.[1] Since traffic demand is increasing,[2] it will eventually be necessary to replace or augment these computers in order that flight information be adequately processed. "Peak," which is an important measure of traffic demand, is defined to be the largest number of in-flight aircraft occurring at any instant in time in any single day. An actively controlled aircraft is an aircraft given services by an enroute controller. The continental airspace is divided into 20 contiguous areas called Air Route Traffic Control Centers (ARTCCs), or centers. The peak IAC is estimated for each center.

This Note describes a pilot study whose principle purpose is to assess the feasibility of developing a mathematical model to predict peaks, and to also characterize peaks. An economical method to estimate peak IAC is highly desirable because it is very costly to process radar target reports, which, prior to this research, had been the accepted way to count aircraft.[1]

The views expressed in this Note are those of the authors but not necessarily those of the Department of Transportation or Federal Aviation Administration.

Characteristic Trends in Actively Tracked Aircraft

Traffic patterns in ARTCCs fall into two classes. In one class, the number of actively controlled aircraft peaks once in the morning and once in the afternoon. These ARTCCs are located on or near the east and west coasts and will be called "terminal" ARTCCs. Figure 1 shows the number of actively controlled aircraft in the Cleveland ARTCC (a terminal ARTCC) as a function of time of day on a typical day of the year in 1979. Other terminal centers include the New York, Boston, Washington, and Los Angeles ARTCCs. Some centers, particularly those in the middle of the U.S., do not exhibit bimodal traffic characteristics, i.e., there are not significant peaks. These ARTCCs are called "enroute" ARTCCs and include Houston, Fort Worth, and Kansas City.

Approach to Peak Estimation

The approach is based on the experimental observation that the largest daily peak in an ARTCC is proportional to total daily aircraft operations in that ARTCC (see Fig. 2). The latter number is obtained from FAA Form 7230-14, while the former number is obtained from processing radar data. Table 1 summarizes the dates and ARTCCs sampled. Using these two sources of data, a linear regression model that predicts peak IAC was developed. Other methods[3] can be used to analyze the experimental data, but these are more costly than regression. By using the partial F-test and a stepwise regression analysis, it was concluded that the relation between peaks and daily operations does not differ significantly from one ARTCC to another, a conclusion which justified pooling all data, thereby increasing the sample size. The pooled data were used to derive a pooled regression model, using the standard Statistical Package for the Social Sciences (SPSS) regression program. The form of the regression equation is $\hat{Y}=AX_0+B$, where X_0 is number of daily operations for a given day, A is the estimated slope of the regression equation, B is the estimated intercept and $\hat{Y}$ is the predicted peak. For Table 2 (overall model), which summarizes peak counts and their tolerances[4] for each ARTCC, $A=0.0308$, and $B=43.6043$. Since it was assumed that the regression model also applies to the 14 continental ARTCCs not sampled, the model was applied to daily operations data from all 20 ARTCCs.

A similar regression analysis was performed on data from the Cleveland Center. The regression parameters were $A=0.0373$, $B=-8.436$.

Because all available data were pooled, the tolerances in Table 2 are larger than they would be if data were not pooled because of the large variations in data among ARTCCs. To test this hypothesis, a regression analysis was done using only the Houston Center's peak and daily operations data (Table 1). Houston was selected because it has the largest number of data samples. Table 2 (Houston model) summarizes results. The regression parameters are $A=0.0525$ and $B=-45.3931$. Tolerances are smaller than those for the overall model.

Table 1 ARTCC daily peak number of actively tracked aircraft and corresponding total daily operations data

ARTCC	Date in 1979	Measured peak number of actively tracked aircraft	Total number of daily operations
Salt Lake City	June 29	179	2369
	Aug. 3	200	2590
Boston	June 10	111	3170
	June 11	107	3580
	June 17	97	2750
Cleveland	June 29	244	7142
	July 9	217	6161
	July 10	263	7197
	July 11	298	7704
	July 12	272	8076
	July 13	284	7338
	Aug. 3	245	6845
Kansas City	July 9	223	4409
	July 10	225	4691
	July 11	228	4612
	July 12	243	4829
	July 13	237	4500
Chicago	June 7	264	7585
	Aug. 1	318	9261
Houston	June 16	114	2938
	June 17	121	3121
	June 23	124	3294
	June 30	111	3143
	July 1	108	3014
	July 4	85	2476
	July 7	129	3316
	July 8	140	3433
	July 14	119	3067

Table 2 Peak air count estimates

ARTCC[a]	Overall model Peak[b]	Overall model Tolerance[c]	Houston model Peak[b]	Houston model Tolerance[c]	Daily operations
Albuquerque	182	88	191	32	4501
Atlanta	222	88	258	55	4784
Boston	190	88	204	36	4742
Chicago	329	95	441	121	9261
Cleveland	270	90	340	84	7342
Denver	165	88	162	23	3954
Forth Worth	232	88	275	61	6104
Houston	220	88	255	54	5725
Indianapolis	223	88	261	56	5832
Jacksonville	192	88	207	37	4804
Kansas City	214	88	245	50	5525
Los Angeles	191	88	205	36	4776
Memphis	217	88	250	52	5623
Miami	169	88	167	25	4054
Minneapolis	219	88	254	53	5694
New York	237	88	283	64	6263
Oakland	171	88	172	26	4148
Washington	228	88	269	59	5993
Salt Lake City	139	89	116	16	3083
Seattle	181	88	189	31	4410

[a] Underlined ARTCCs have a range of daily operations that are out of the ranges of the ones used for the Houston model. [b] Busiest day in August 1979. [c] 99% confidence, one-tailed t-test.

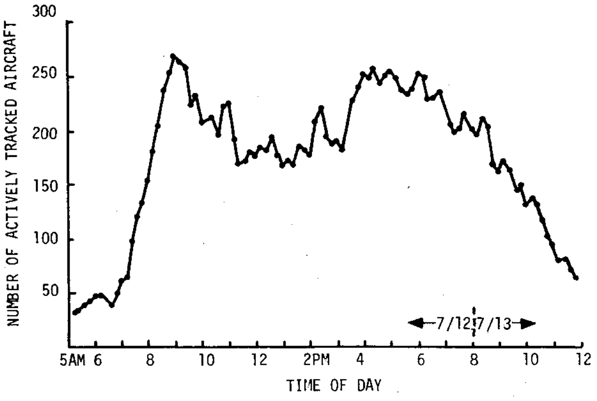

Fig. 1 Number of actively tracked aircraft in Cleveland ARTCC vs time of day, July 12, 1979.

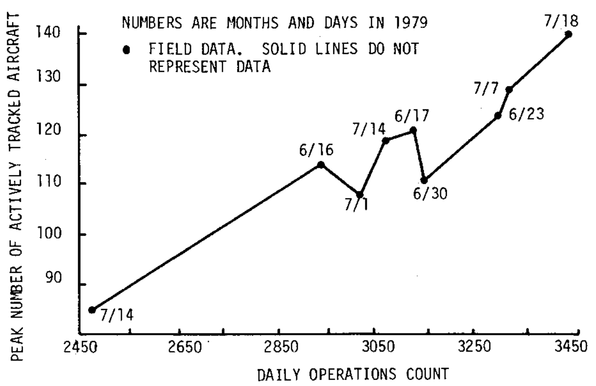

Fig. 2 Peak number of actively tracked aircraft in Houston ARTCC vs number of operations.

Interpretation of Principal Results

In the last section, linear regression was used to derive a relationship between peak IAC and operations data. This section derives the same relationship theoretically. Approximate all air activity by one constant pulse with a 12-h window (see Fig. 1). The average number of operations per hour is $X/12 = (0.083)X$, where X is the total number of daily operations. There are two terminal operations per in-flight aircraft, i.e., for every arrival there is a departure. This relationship is approximately true during busy times, for a busy airport within the ARTCC cannot allow for long a significant excess between arrivals and departures. The number of overflights (for a terminal ARTCC) during periods of peak morning activity are relatively small. The peak count is therefore $(1/2)(0.083)X = (0.042)X$. The estimated slope, 0.042, agrees very well with the actual slope, 0.037.

Houston (an enroute ARTCC) is likely to have a significant number of morning overflights. There are two terminal operations per in-flight aircraft, but one overflight operation per in-flight aircraft. There are therefore an average of three operations for every two in-flight aircraft. The peak IAC is $(2/3)(0.08)X = (0.05633)X$. The slope 0.056 agrees closely with the slope of the regression curve, $A = 0.053$.

The foregoing physical interpretations are simplistic, but they do suggest that regression models describing terminal and enroute centers are possible.

Conclusions

Analysis of preliminary data (Table 1) suggests that a regression of peak number of actively controlled aircraft on total daily operations is a feasible way to economically estimate the peak IAC over various ARTCCs. The method is attractive because operations data are easy to acquire. It is possible to have one general regression model for the entire continental U.S. or separate models for each ARTCC. The "noise" in the former (i.e., the standard error of estimate) would depend on the "noise" in the latter models. For example, the standard error of estimate for the overall model was $\hat{\sigma} = 34.7$, whereas for the individual Houston model, $\hat{\sigma} = 5.1$.

Peak models for terminal and enroute centers appear possible, and improved estimates of peak IAC might be possible by regressing not on total daily operations but, instead, on their component operations, which consist of arrivals, departures, and overflights. An important question might be answered: Are individual model parameters required for each ARTCC, or can models be devised that are applicable to two or more centers as a group?

A more comprehensive sampling and analysis plan to obtain new data from all ARTCCs will be used to validate these results. Daily, weekly, and possible seasonal effects will also be analyzed. The original regression model, which regressed on only one variable, may eventually be replaced by an improved model that regresses on several variables. However, it is unknown if there will be a significant improvement in model accuracy. Finally, the limited number of samples (Table 1) probably means that the tolerances in Table 2 may not be very accurate. However, preliminary engineering planning does not require precise accuracy in peaks or tolerances.[5]

Acknowledgment

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Air Traffic Control Computer Performance in the National Airspace System

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Introduction

THE Federal Aviation Administration operates a nationwide enroute air traffic control system which is supported by several dedicated computers. This equipment

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