TECHNICAL DEVELOPMENT REPORT NO. 340

FEASIBILITY OF USING A GENERAL-PURPOSE COMPUTER IN THE CENTRAL ALTITUDE RESERVATION FACILITY

FOR LIMITED DISTRIBUTION

by

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February 1958

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INDIANAPOLIS, INDIANA

FEASIBILITY OF USING A GENERAL-PURPOSE COMPUTER IN THE CENTRAL ALTITUDE RESERVATION FACILITY

SUMMARY

This report describes a study to determine the feasibility of using a general-purpose computer at the Central Altitude Reservation Facility at Kansas City, Missouri It is concluded that a medium-size digital computer with large storage capabilities could be programmed to process airspace reservation requests, detect conflictions between missions, and suggest changes in altitude or time of the missions to resolve conflicts. It is not considered feasible to program existing types of computers to resolve conflictions by suggesting changes of route It is also concluded that it is not practical to use a single computer for both the Central Altitude Reservation Facility and the Kansas City Air Route Traffic Control Center.

INTRODUCTION

On September 30, 1957, the CAA Office of Air Traffic Control (OATC) requested that the Technical Development Center (TDC) study the operations of the Central Altitude Reservation Facility (CARF) to determine the feasibility of performing some of the CARF functions with a computer Since a computer already was planned for the Kansas City Air Route Traffic Control Center (ARTCC), specific interest was expressed in the possibility of programming this computer to handle both operations, or determining the size and type of computer equipment appropriate for both operations

During October, November, and part of December, 1957, TDC personnel made a study of the CARF operation, and developed flow diagrams for computer processing This report is based on that study

DESCRIPTION OF PRESENT CARF OPERATION

Certain high-altitude military aircraft missions obtain airspace reservations in advance from the CAA to eliminate unwanted changes in flight plans after the start of a mission Requests and approvals of these airspace reservations may be made from several hours to several days prior to the proposed departure time The CARF at Kansas City was established to minimize the coordination of these airspace reservations. Previously, each ARTC Center was responsible for all coordination required by missions originating in its area At present, CARF is responsible for approving and coordinating changes in flight plans of military missions in the United States and over adjacent oceanic areas above 14,000 feet altitude east of the 100th meridian, and above 24,000 feet altitude west of this meridian. This facility receives proposed flight plans of military missions, detects and resolves conflicts between such missions, and forwards approved airspace reservations to the appropriate air bases and air traffic control (ATC) facilities.

Normally, the military unit originating the mission submits its airspace reservation request to the ARTC Center where the departure point is located. These requests are generally made at least two days before the scheduled departure After coordination between the mission officer and the ARTC Center where the flight will originate, the ARTC Center edits the request and forwards it to CARF via Schedule B teletype.

When received at CARF, the airspace reservation request is plotted on a plastic overlay on top of charts of the United States All route segments, altitudes, control times, and refueling areas are included in the plot Conflicts between missions are detected during the plotting process and usually are resolved by arranging for a change in altitude, route, or departure time When a number of missions are proposed at the same time, the resolution process can become complex and time-consuming, frequently requiring several discussions between CARF and one or more mission officers Certain missions, such as navigation training, are of such a nature that the flight area is unimportant. When a conflict arises involving such flights, CARF may be asked to suggest, by reference to its plots of other missions, areas where such flights may operate at the time requested In other missions, arrival at a certain point at an exact time is important but the route is not important In these cases CARF may suggest alternate routings

Mission priority normally is the primary consideration in conflict resolution. However, where conflictions can be satisfactorily resolved only by changes in route, a higher priority mission is sometimes changed when it conflicts with a mission of lower priority, if by so doing fewer changes are required and the commands are agreeable

Occasionally, last-minute requests for changes to previously approved reservations are received. These changes usually affect route, refueling area, or departure time. CARF makes an effort to coordinate these changes and issues revised clearances provided the requests are made four hours in advance of departure time

After conflictions have been resolved, a mission-approval message is composed and transmitted by teletype to the originating ARTC Center and all other Centers concerned In any case, all ARTC Centers involved are advised at least 12 hours before the proposed departure time

The CARF Annual Statistical Report covering the period from August 1956 to August 1957 shows that a total of 3,090 altitude reservations were processed. The peak activity day for this period occurred in August 1956, when 54 altitude reservations were recorded. The average of monthly peak days was 24 altitude reservations, while the daily average of reservations during the week varied from 2.6 on Sundays to 13 5 on Wednesdays

PROPOSED APPLICATION OF COMPUTER TO CARF OPERATION

Based on previous experience in programming the IBM 650 RAMAC and the Univac Model 1 computers, it appears that either machine, or similar machines, could be used to do part of the CARF problem For the purpose of showing feasibility, one of these computers, the IBM 650 RAMAC, was selected The following analysis indicates how much of the problem can be assigned to the IBM 650 RAMAC and how this can be accomplished

In order to estimate storage requirements and processing time, it was necessary to determine certain message characteristics Analysis of altitude reservation requests for the month of July 1957 indicated an average of 9 missions per day composed of 30 route segments each The number of alpha-numerical characters required for identification of missions, cells, and flights also was determined from this sample

Input.

Punched cards would be used to enter information into the computer. The first two cards would contain.

1. The mission identifier
2. The cell identifier
3. The flight identifier
4. The date and time of takeoff
5. The priority of the mission
6. The void time of the mission
7. The elapsed time to landing for each cell

The next several cards would contain altitude and route information as follows:

1. Fixes designated by longitude and latitude.
2. Elapsed times from one fix to the next
3. The altitude between fixes

Assuming an average of 30 fixes per mission, an additional 8 input cards would be required for this information

The punched cards would be read into the computer and the information stored in temporary storage locations The longitude and latitude of the fixes would be converted from degrees and minutes to degrees in decimal form The elapsed time between fixes would be converted from minutes to decimal equivalents in hours The heading between fixes would be calculated and stored Hence, the machine would have stored consecutively (1) fix, (2) altitude and time, and (3) heading to next fix This series would be repeated in the same order for each fix

Conflict Detection

When a new proposed mission is entered, the first approved mission that is already in permanent storage for the same day would be brought into high-speed storage A comparison by time first would be made to determine whether the missions conflict and at what hours the conflict exists If the two missions are not in the air within two hours of the same time, the next mission will be brought into high-speed storage from the RAMAC and its time of takeoff and landing compared with that of the new proposed mission When both missions are in the air within two hours of the same time, it is possible that the two missions may conflict and a time search would then be made between the route segments of both missions

Each of the segments of an approved mission would be compared with the segments of the proposed flight, with which a time conflict is found, to determine whether they are in the same geographical area If they are not in the same area, no further check is necessary and the next mission would be brought into high-speed storage from the RAMAC If any segment of the approved flight is in the same geographical area as a segment of the proposed flight, an altitude comparison is made. If there are no altitude conflictions, the next mission would be checked If the altitude comparison reveals a possible conflict, the flight paths involved would be solved as simultaneous equations to determine if the flight paths intersect or pass close enough to create a conflict If there is a conflict, the computer will store the location of the confliction and continue to the next mission If there are no conflictions the machine will go directly to the next mission

Conflict Resolution.

For the present, it does not appear feasible to program the computer to resolve conflicts requiring a change of route It does appear possible for the computer to suggest solutions to conflicts on the basis of altitude and time changes To do this it would be of considerable assistance if the route segments of the original request were coded to indicate whether an altitude and/or time change would be accepted and how much of a change would be allowed. However, for this study it has been assumed that this coding is not provided

It has been assumed that altitude revisions of plus or minus 4,000 feet might be considered Therefore, when a confliction is found, a change of altitude within these limits would be tested In determining a possible solution, the proposed altitude would be checked with the preceding and following segments to determine whether this change would affect refueling or landings planned in the next segment. Also, it would be necessary to check a possible altitude change against all other missions operating at the same time in the same area After a possible solution is determined, it would be stored for later punch-out as an output message.

Whether an altitude revision would solve the conflict or not, a time change also would be tested in a manner similar to that used for the altitude change. It is proposed to test time changes up to 4 hours, or multiples of 12 hours These time changes would require retesting of of the mission's segments for possible conflicts The first possible time solution found would be stored to be later punched as part of the output message

If a previously approved mission of lower priority conflicts with the proposed mission, then the lower priority mission would be tested by the method outlined above

Output

There would be two types of computer output messages, one if no conflict has been found, and one if a conflict has been detected The first type message would contain the identification of the mission and the complete route of flight It appears also that it would be possible to compute the time of passing and the distance and direction from normal radio fixes posted on ARTC Center control boards as additional items for output to simplify posting in ARTC Centers These cards would be sent through a card-to-tape converter, and any special messages added before teletypewriter transmission to the Centers and bases concerned.

If a conflict is detected, the output message would contain the identification of the proposed mission and the location, time, altitude and identification of the cells and missions with which it is in conflict Suggested altitude and time changes which would resolve the confliction would be included in this output Coordination of possible conflict solutions with the mission commanders involved would be left to the CARF controller From this information it also would be possible for the controller to plot the problem area in the event that a route change is the only acceptable solution. The original mission information plus the suggested changes to resolve the conflict would be stored pending this coordination action. After an acceptable change in flight plan has been agreed to, the method of resolution decided upon must be put into the computer

In those instances when CARF is requested to suggest an operational area for a training flight, a short routine could be developed which would analyze all stored data and produce a tabular output of activity in designated areas under CARF jurisdiction These data can be as general, or specific, as required to assist this planning function and should not require any flights to be plotted in order to provide this service.

Coordinate System

The coordinate system proposed is a modified rectangular system using longitude and latitude Corrections are applied to the slope (heading) based on the latitude of the area being processed For example, the slope of a path between two points is

$$m = \frac{y_2 - y_1}{x_2 - x_1} \tag{1}$$

where
y_1 and y_2 equal latitudes of points 1 and 2 .
x_1 and x_2 equal longitudes of points 1 and 2

The slope with a correction applied is

$$m_c = \frac{60}{a} \quad \frac{y_2 - y_1}{x_2 - x_1} \tag{2}$$

where
a equals average number of miles per degree of longitude between points 1 and 2, based on 60 miles per degree latitude

This average a can be computed from the formula

$$a = \frac{a_1 + a_2}{2} \tag{3}$$

where
a_1 equals 60 cos (latitude of point 1)
a_2 equals 60 cos (latitude of point 2)

A cosine table for each degree from 0° to 90° would be stored for reference in this computation

To determine how accurately these calculations would compare with positions and courses determined by reference to charts, a series of measurements were made using USAF Jet Navigation Charts (Lambert Conformal Conic Projection) between 25° and 74°, north latitude.

Many combinations of line segments, line lengths and intersections were drawn, located, and measured by reference to these charts The line lengths, locations and intersections were then computed and compared using the above slopes m and m_c. Close agreement was obtained at the lower latitudes, with the errors increasing further north Errors in the line length did not exceed 2.5 miles per 100 up to 75° north At 89° the error is 7 miles per 100

If the polar region north of 75° is of concern, there are several possible coordinate systems which should be considered. The two most promising appear to be polar and spherical projections. There was not sufficient time to evaluate or compare these; however, it is believed that development of a special routine for the polar area would not be a serious problem

POSSIBILITY OF JOINT CARF/ARTCC USE OF SAME COMPUTER

There are two ways in which a computer might be used jointly by CARF and the Kansas City ARTC Center One way would be to assign the computer during certain hours or one shift of the day, for example, the normal light traffic periods in early morning, to CARF, and use it for ARTC Center problems the rest of the day Another way would be to have both CARF and ARTC Center program routines in the computer, and switch the input and output from one to the other in accordance with some priority schedule.

In the first scheme the computer probably would not be available to CARF for 16 hours or more each day This implies that the memory of the machine, dealing with the previously approved flight plans, would have to be plotted at the end of each CARF machine period to make the record available as a reference during the remainder of the day Plotting these data would require almost as much manpower as plotting the data manually, without using the computer. Also, the computer would not be available to assist in detecting or resolving any conflicts resulting from late revisions except during the hours assigned to CARF machine processing. Since almost the same manpower would be required and CARF's service would not be improved, it would be of little value to use a shift-shared computer. Consequently, this mode of operation is not recommended.

On a priority time-shared basis, it is necessary to consider the computing time required to solve both CARF and ARTC Center problems. In a machine having the storage and speed of the IBM 650 RAMAC, it is estimated that 5 minutes is required to test a proposed mission having 30 route segments against a similar already stored mission. Assuming 5 stored missions as an average daily condition, then 25 minutes will be required to make a conflict search. An additional three minutes will be required for input and output and final storage Each conflict resolution will require approximately two minutes. To enter a mission, check it against 5 already approved missions, resolve one conflict and store and punch the output, will require about 30 minutes. If it is assumed that the real time ARTC Center problems are given priority, the CARF process would be interrupted, the number and length of interruptions depending upon the existing traffic conditions in the ARTC Center area and the extent of machine time required for processing ARTC Center problems. During heavy traffic periods, particularly if the computer also does conflict search for the ARTC Center, it is likely that the ARTC Center would capture the computer to the exclusion of CARF for an hour or more at a time

Questions arise as to whether a faster program might be devised for both CARF and ARTC Center to conserve computer time, or whether a machine faster than the IBM 650 RAMAC might be better suited for both jobs. The study has not advanced far enough to indicate whether these time estimates can or cannot be improved, although it should be assumed that they probably can. On the other hand, it seems logical to assume that it will become increasingly desirable to program the machine to do more work for both activities than has been assumed here, and this desire would tend to offset savings that might be made in program time.

The next sizes of larger and faster computers are quite expensive. In the time allotted for this study, the idea of using a faster machine was not explored except to determine that the cost of typical machines is approximately four times as much as the IBM 650 RAMAC. It is, therefore, more economical to provide independent medium size computers for both CARF and the Kansas City Center than to use one larger computer for both facilities.

In the available study time, it was concluded that there would not be enough machine time to do both CARF and ARTC Center problems satisfactorily on one medium-size general purpose-computer, such as the IBM 650 RAMAC.

SIZE AND TYPE OF MACHINES REQUIRED

To determine the size and type of electronic digital computer required to perform the conflict search and limited conflict resolution, it is necessary to consider the amount of information which must be stored in the computer and the number of missions which must be processed per day.

Based on the present operating practices, the computer must be large enough to store all flights for a 12 day period. For example, assume that the average number of missions per day is 9, and the maximum number of missions occurring on any one day is 54. Assume further that there are 11 average days and one maximum day every 12 days. Then, the storage requirement for approved missions would be approximately 420,750 characters. In addition, about 240,000 characters are needed to define restricted (or prohibited) areas, 60,000 characters for refueling areas, 120,000 characters for coded flight plan routes which are used repeatedly, and 15,000 characters for tables. Under these assumptions the total storage requirement will be about 855,750 characters. This is about 20 per cent of the storage available in the IBM 650 RAMAC. It is visualized that the restricted areas would be stored on 4 disc faces, the refueling areas on 1 disc face, the coded flight plans on 2 disc faces, the tables on 1 disc face, the computer program instructions on 1 disc face, and the missions on 12 disc faces, thereby using 21 of the available 100 disc faces. The storage capacity of each disc face is 60,000 characters

General program routines for the conflict search and limited conflict resolution were developed for the IBM 650 RAMAC. It was found that approximately five minutes would be required to check completely one new mission against one mission in storage and two minutes to resolve by change of altitude each conflict found Also it takes approximately three minutes to enter and process a new mission for storage and to punch the output. Thus, if there were 5 missions in storage and a new flight being entered conflicts with each of them, it would take about 38 minutes to put the new flight into the computer, do a complete conflict search and conflict resolution with each of the five flights which are on the same day, and to punch out the resultant message. It is reasonable to assume, however, that it will not be necessary to make a complete conflict search and conflict resolution with each of the five missions already stored. For example, if one mission does not conflict in over-all mission time, a second does not conflict when a geographic check is made, a third does not conflict when an altitude comparison is made, a fourth does not conflict when the route segments are calculated, and the fifth does conflict; then, only 20 minutes (approximately) would be required to process the new mission.

The number of assumptions which can be made is unlimited and it is therefore difficult to predict ultimate machine capacity. Table I can be used to predict the time required to process a new mission. Across the top are the number of missions assumed to be in storage for any one day. On the left side is the sequential order of new missions to be entered for that day. Time is shown for input/output and assumptions ranging from one to five minutes for the time required for conflict detection are made. These detection times vary depending upon where in the search it is determined that a conflict does not exist. Each conflict resolution by change of altitude requires two minutes of machine time per mission in storage. Each conflict resolution by change of mission departure time requires from two to five minutes of machine time per mission in storage Thus, it can be seen that the tenth mission for a particular day requires 3 minutes for input/output, 31 minutes for conflict detection and 6 minutes to resolve 3 assumed conflictions by altitude change. This is a total time of 40 minutes. In a similar case, resolution of 2 conflictions by altitude changes and 1 confliction by time change requires 22 to 49 minutes, or a total time of from 56 to 83 minutes to completely process the tenth mission. Referring to the table, if missions Nos 1 through 10 for one day are received, it would take a total of 3, 4, 5, 8, 13, 18, 19, 26, 31 and 40 minutes, or 2 hours, 47 minutes to process these missions.

As another example, assume there are 25 missions already in storage for a particular day. Missions Nos. 26 through 35 (total of 10) would take about 30 hours, or more than one day, to process.

It should be remembered, however, that the maximum number which can be processed under certain conditions in any one day does not completely determine the usefulness of the computer, since the work is not time-critical. Those days with only a few stored missions require very little time to process an additional new mission. These light days tend to balance the time required on heavy days.

EFFECT OF COMPUTER ON PRESENT CARF OPERATIONS

The application of a computer to CARF would require changes in some of the present practices and procedures if all of the benefits the computer offers are to be realized. A few of the more significant changes are explained in the following paragraphs.

Flight-Plan Format, Editing, and Coordinate System.

During the study of the CARF operation it was indicated that the military would prefer to file flight plans with fixes or turning points specified in latitude and longitude. The input/storage philosophy developed in this study was directed toward satisfying this preference. The flight-plan format would define route segments approximately 300 miles or less in length with end points designated by latitude and longitude. It is believed that the fixes in the approved output messages to the ARTC Centers concerned could be translated by the computer to the three-letter fix designators. This would eliminate the present objection ATC has to receiving flight plans filed in latitude and longitude.

A change in the method of filing mission requests is under consideration. This new scheme would make it unnecessary for the initial request to pass through the ARTC Center in which area the mission will originate. Rather, the mission would be filed with the agency's headquarters such as Strategic Air Command (SAC) at Omaha, Nebraska. SAC would screen the request and forward it to CARF. Further coordination on this request would be conducted between CARF and SAC headquarters. This proposed procedure would work very well with the computer. Requests and coordination between CARF and SAC could use longitude and latitude, and when approved, the machine could convert the flight plan to the ATC coordinate system based on three-letter fix designators.

Display Requirements.

The most significant change the computer could make at CARF would be in reducing the workload of preparing plotting displays. Rather than plotting all incoming requests as presently is done, the computer could store all of this information in its memory. Such a philosophy is dependent upon extreme machine reliability and assumes that temporary outages, when they occur, are not of major consequence. These assumptions appear justified. The costs of machine rental, discussed later, include a maintenance engineer on continuous duty. The probability of failure is low in the first place and the ability to repair the machinery in a short time, at least to the extent that stored missions can be read out, approaches 100 per cent. As an ultimate backup, hard copies of approved missions could be kept on file and plotted manually, if required. It should be noted that CARF is not involved with "real" time problems. Most of the time the computer would be working on reservations 2 to 10 days in advance. Unless advantage is taken of computer memory to reduce the amount of manpower now expended in plotting missions, the computer would be of little time or economic advantage.

As has been indicated, the computer program could suggest changes in altitude or time of the mission to eliminate conflictions. The majority of conflictions are resolved in this manner today When it is necessary to resolve a conflict by changes in routing, it would be necessary for CARF personnel to plot certain segments of two or more missions manually. The computer output message would contain the complete conflict situation, such that plotting should not be very time consuming. At a later date it may be possible to provide a display which will automatically plot information stored in the machine. Such a device is not under development at this time

Estimate of CARF Capacity and Service Capability.
The application of a computer should allow CARF to operate with increased capacity with no increase in manpower At the present traffic level, the computer should allow some reductions in manpower, as indicated later in this report.

At the present time, CARF does not consider flight plans which are not filed at least two days prior to the scheduled departure time, nor will it accept revisions to flight plans which are not received at least four hours prior to departure time. These restrictions are based not only on CARF capacity but also consider the coordination time with ARTC Centers and other agencies involved. With a computer, it may be possible, without increased staffing, to receive and modify flight plans on shorter notice by depending on the computer to do the plotting and confliction search work, thereby releasing more personnel time for coordination.

The RAMAC machine has more storage available than this study proposes to use However, many other functions, such as statistical analysis, could be accomplished also.

ECONOMIC FACTORS

Present CARF Personnel Cost.
Based on information received from CARF and Region Three, approximately 25 personnel are presently employed at CARF, whose salaries total approximately $160,000 per year. Present staffing during the week averages six control personnel on the 0800 - 1600 watch, five on the 1600 - 2400 watch, and one on the 2400 - 0800 night watch On Saturdays and Sundays the present staffing averages four, four, and one, respectively, for the three shifts. CARF personnel estimate that 50 per cent of their time is devoted to plotting and conflict detection and 50 per cent to conflict resolution and communications.

With a computer system performing the plotting, conflict search, and limited-conflict resolution, a substantial part of the workload should be eliminated. The need to communicate with the originating agency requesting clearance would be unchanged, as would be the time and methods required for such communications. It is estimated that one person would be required to edit the information coming into CARF, punch the cards, and run the computer Other personnel would be required for coordination with the originating agency and the ARTC Centers involved. When a conflict can be resolved only by route change it would be necessary to plot the conflicting route segments

If a computer were installed, it is estimated that control personnel staffing could be reduced to four on the day shift, three on the evening shift, and one on the midnight-to-eight shift with weekend staffing of three, three and one. The resulting salary expenditure would be approximately $108,000 per year.

Machine Costs.

An IBM 650 RAMAC system would consist of the following

Unit	Monthly Rental/First Shift
650 Model II, Console	$2400.00
655 Model I, Power Unit (With Input-Output Synchronizers 1 and 2)	1100.00
652 Model B1 Control Unit	975.00
653 Model B3, Storage Unit	1900.00
355 Disc Unit	975.00
533 Card Reader	550.00
No. 13 Alphabetical Device for 533	175.00
No. 14 Alphabetical Device for 655	75.00
Half-Time Emitter for Punch	5 00
Ten extra Pilot Selectors	20 00
026 Printing Card-Punch	60.00
063 Card-to-Tape Converter	75.00
Total	$8310.00

The above rental cost is for the first shift only which is defined as 40 hours per week. Each succeeding 40 hours per week would cost an additional 40 per cent. Assuming full-period operation, with 8 hours per week for preventive maintenance, three additional shifts would be required at all times. The cost of this full-period service would be approximately $18,300 per month or $220,000 per year. These costs include IBM maintenance and continuous duty of qualified maintenance personnel.

It is estimated the cost of materials required, such as cards, should be less than $500 00 per year.

Summary of Cost Estimates.

ANNUAL COSTS

	Present (No Computer)	With Computer
Personnel	$160,000	$108,000
Computer System		220,000
Additional Materials		500
Totals	$160,000	$328,500

It is assumed that other costs such as rent, landlines, heat and air conditioning remain approximately the same whether the machine is used or not.

CONCLUSIONS

It is concluded that

1. Much of the processing of airspace reservation requests by CARF is within present-day computer capabilities. By use of latitude and longitude to describe the route of flight, the mathematical processes involved are relatively simple. The storage requirements can be met with computers similar in size to the IBM 650 RAMAC.

2. Use of a computer is feasible if its memory is used in lieu of manual plotting, and its computing functions are used to detect conflicts and suggest resolutions on the basis of altitude and time changes.

3. Conflict resolutions based on changes of route are not feasible machine functions with available equipment

4. The introduction of a computer should not have revolutionary effect on the present CARF or ATC system.

5. The use of a single computer by both the Kansas City ARTC Center and CARF does not appear feasible.

6. The savings in manpower will not economically justify the cost of a computer for CARF, however, greater capacity and better service can be expected from a smaller CARF complement by using a computer.

TABLE I

PROCESSING TIME IN MINUTES AS COMPARED TO OTHER MISSIONS

Number of Mission in Storage

Number of Mission Entered	input - output	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	number of conflicts	Total Time
1	3																																																			3
2	3	1																																																	4
3	3	1	1																																															5
4	3	1	1	3																																													8
5	3	1	1	3	5																																												13
6	3	1	1	3	3	5																																										1	18
7	3	1	1	1	3	3	5																																									1	19
8	3	1	1	1	3	3	5	5																																								2	26
9	3	1	1	1	3	3	5	5	5																																							2	31
10	3	1	1	3	3	3	5	5	5	5																																						3	40
11	3	1	1	1	3	3	3	5	5	5	5																																					3	41
12	3	1	1	1	3	3	3	3	5	5	5	5																																				4	46
13	3	1	1	1	3	3	3	3	5	5	5	5	5																																			4	51
14	3	1	1	1	3	3	3	3	3	5	5	5	5	5																																		5	56
15	3	1	1	1	3	3	3	3	5	5	5	5	5	5	5																																	6	65
16	3	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5																																7	72
17	3	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5	5																															8	79
18	3	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5	5	5																														9	86
19	3	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5																													10	93
20	3	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5																												11	100
21	3	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5																											12	103
22	3	1	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5																										13	110
23	3	1	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5																									14	117
24	3	1	1	1	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																								16	130
25	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																							17	139
26	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																						18	146
27	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																					20	155
28	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																				21	162
29	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																			22	169
30	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																		23	176
31	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																	24	183
32	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5																25	190
33	3	1	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5															26	197
34	3	1	1	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5														28	211
35	3	1	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5													30	221
36	3	1	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5												31	228
37	3	1	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5											32	235
38	3	1	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5										33	242
39	3	1	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5									34	249
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41	3	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5							36	267
42	3	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5						37	274
43	3	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5					38	281
44	3	1	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5				39	288
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