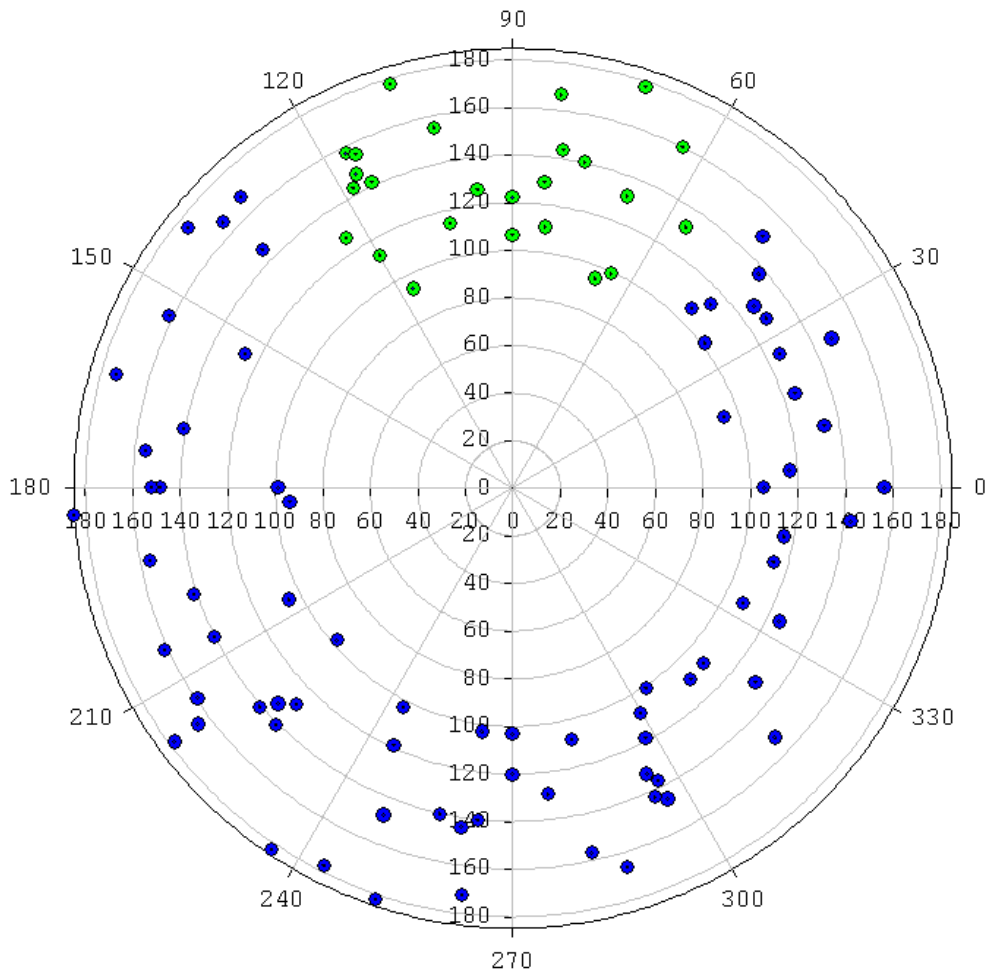


FACILITATING US AIRSPACE EMERGENCY PROTOCOL

A COMPUTER BASED EXPERIMENT OF AUTOMATED AIR TRAFFIC CONTROL SYSTEMS

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Las Cruces, New Mexico

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E.0 EXECUTIVE SUMMARY

The purpose of this project is to experiment, explore, and as well as to develop, new methods of autonomous air traffic control systems. The US air traffic system today faces greater challenges than ever before. Air travel has increased dramatically since the US federal government deregulated the airline industry in the 1970s. However, the construction of new airports and runways has not kept pace with the increase in air traffic. This has put excessive pressure on the air traffic control system to handle the nearly 50,000 flights per day, a number projected to increase in the near future. In fact, by 2015, air traffic is expected to double altogether. This shall not be the end of the woes for air traffic control. A massive efflux of air traffic controllers at airports is expected in the near future as the main work force is poised to retire.

Air systems the world over, diseased with the steady tide of ever increasing traffic and the slow hemorrhage of controllers, shall inevitably fail if nothing is done to correct this situation. The word air traffic control, it in itself shall come to lose its integral meaning. A failed airspace system can only cripple industry, halt economies and exponentially raise disaster rates. This is not a problem to be dealt with in the future— it is a problem that has already taken effect.

Recently, the Federal Aviation Administration (FAA) has reinforced its mandate that all airports must have at least two air traffic controllers (ATCs) on duty at all times. An investigation done by the FAA revealed that, prior to this, smaller airports have routinely operated one man shifts, an increasingly common but equally dangerous practice. It was at an airport manned by only one ATC that in Lexington, Ky., a plane attempted to takeoff from a closed runway, killing 49 people aboard.

Thus far, we have successfully created an Autonomous Air Traffic Controller, which specializes in facilitating the flow of air traffic during emergencies. It provides a method which shall be perhaps a temporary theory, but for the time being an effective step in averting a disaster. This project is not just an experiment on what is possible, but an insight into the inevitable, into the future of automated air traffic systems.

1.0 INTRODUCTION

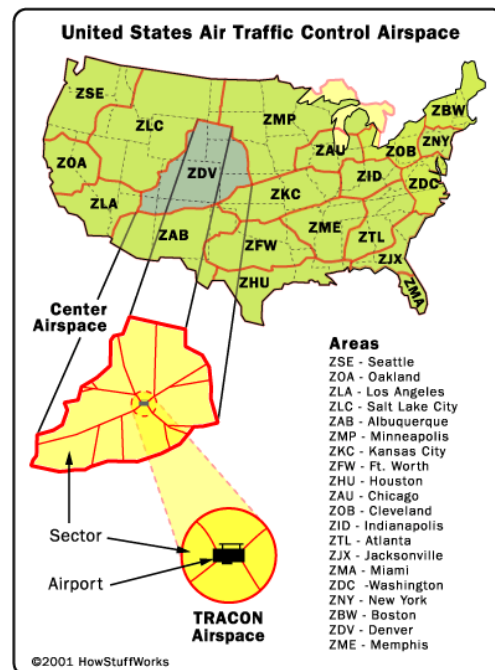
1.1 Background Information:

The airplane is arguably one of the greatest advances in transportation technology. Its invention meant that transportation was no longer restricted solely to the land and the sea, nor to the constraints of two dimensions. Trade, travel, commerce and connectedness could expand beyond the horizons faster than ever. Today in the US, one can find over 5,000 aircraft in the sky every hour.

The monumental task of ensuring the safe operations of all these aircraft falls on the air traffic controllers. They are responsible for the movement of thousands of aircraft, working in perfect synchronization to coordinate a smooth continuous rhythm of air traffic with minimal delays.

Alongside this task, they must also ensure that no airplane enters the vicinity of another, direct them during landing and takeoff, as well as rerouting around bad weather.

The American airspace in the US is divided into 21 zones, with each zone divided into sectors (see figure above).



Each zone contains areas of airspace 25 miles (km) in radius, called TRACON (Terminal Radar Approach CONtrol) airspaces. Within the TRACON airspace is a cluster of airports with an independently controlled airspace of a 5 mile (km) radius.

The air traffic control system has been designed around progressively smaller divisions, relative to the size of their domain airspace by the Federal Aviation Administration (FAA):

- Air Traffic Control System Command Center (ATCSCC) oversees all air traffic control in the US. It also acts to manage areas in which there are problems (e.g. bad weather, excessive traffic load, etcetera).
- Air Route Traffic Control Centers (ARTCC) is the manager of all aircraft within a sector except for TRACON airspace. Each zone (center) has one ARTCC.
- TRACON deals with departing and approaching aircraft within its airspace.
- Air Traffic Control Tower is located at every airport with regular scheduled flights. Towers handle all local traffic including ground traffic.

2.0 PROJECT PROPOSAL

2.1 Project Description

This project develops and refines methods automating and “autonomizing” air traffic control. Computational programs are created in several different languages to experiment, and based upon the experimentation, develop a finished model of a fully autonomous and automated air traffic control system. The basis of this study is to provide a foundation for future experiments into automating air traffic systems. All computer programs must do two things: 1.) create a modeled environment and 2.) simulate the responsibilities of a human air traffic controller within said environment. Therefore the results and data output comes in two forms: the model itself, which is either an input or randomly generated (and carries no true significance as data), and the output generated by the program acting in place of a human. We shall use Java, Excel and Starlogo programming languages.

3.0 CODE METHODOLOGY

3.1 Introduction

This project used four programs and three methods of programming. Starlogo was the original programming language of this project due to its ease of use and highly graphical representation of virtual objects. However, in time, Starlogo was decided against in favor of Java's (Sun Microsystems) flexibility and more powerful computing capabilities.

As information was being converted into graphs using spreadsheets on Excel, it was realized that for two programs coded in Java, that Excel could execute the same function with equal accuracy and ease.

3.2 Program Introduction

The four programs were:

- 1.) The Emergency Clearance Program (ECP)
- 2.) The Clearance Program (CP)
- 3.) The Multi-Airport Clearance Program (MCP)
- 4.) The Total Autonomous Air Traffic Control Program (TAATCP)

The second and third programs were experimental but led to the creation of the flagship programs, the Emergency Clearance Program and the Total Autonomous Air Traffic Control Program.

3.3 Program Analysis

Note: All objects pertaining to any program is capitalized, e.g. Pilot, rather than “pilot”, as to distinguish it from its normal term.

Universal Objects:

- The Plane: The Plane is an object common to all programs which stores information such as its own location, name, destination, speed and other factors.
- The Airport: The Airport is an object also common to all program which stores information such as its own location, name, two arrays (later explained in the text), and other factors.
- The Pilot: The Pilot is not actually an object as it is never instantiated. Its main function is to act as a sort of calculator and pilot. Its piloting function is to take each Plane’s destination and search the arrays in that airport, those arrays being array A and array D. Array A is the arrival array, and the array D is the departure array. Each array signifies the usage, or state, of the runways. Each element in the arrays signifies a time. If a particular element has a value of 1, then it is currently, at that particular period in time, occupied. If it is 0, then the runway is free to be used. The Pilot searches for this “0”. This process is explained in further detail in the text.

3.4 Emergency Clearance Program (ECP)

The first program is called the Emergency Clearance Program (ECP). Its goal was to

1. Aid the ATCSCC (highest) echelon by making recommendations for planes outside a closed sector’s airspace of where to land

In other words, the ECP's task is to take over during emergencies and recommend to the ATCSCC—the echelon which coordinates air traffic during foul weather, emergencies, etcetera—of where to send stranded aircraft. Airplanes whose final destination was inside a closed sector must find a place to land, invariably, at the closest location. ECP simply locates the nearest airport to each airplane, assigns it that destination to land, and notifies ATCSCC and the particular airport of the plane's arrival.

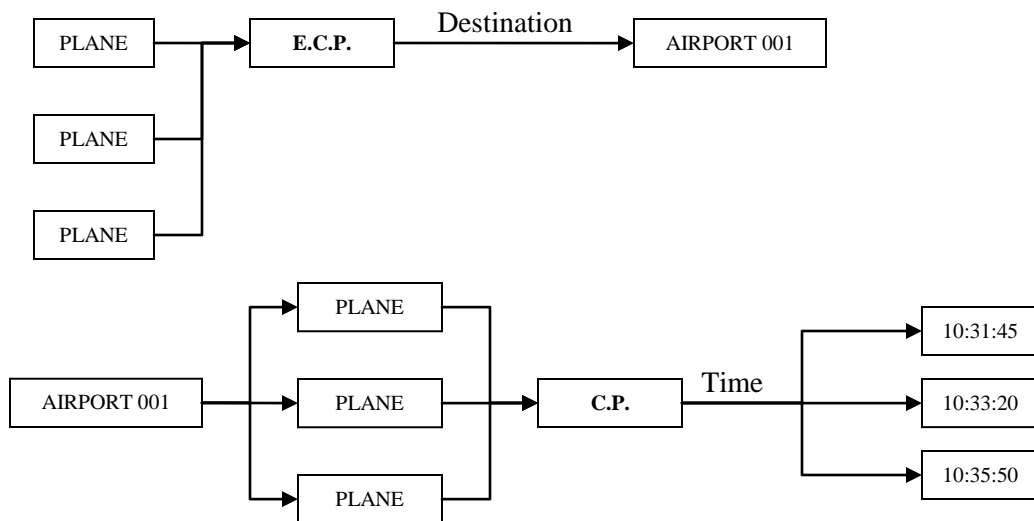
ECP's goal was to find the nearest airport to each plane. All this tasks entails is simply finding the distances between the myriad of airplanes and however many airports there are in the environment. (Towards the later stage of this project, it was found that Excel executed this task just as well as Java did, however more visually and interactively. The advantage of using Excel for this program surpasses Java, and is unfortunate that this realization came too late.) The closest airport is then assigned to each plane. It is from this point that the program's output is used for the input in CP, and all that ECP does is complete.

A program such as ECP automatically alleviates the stressful situation brought upon ATCs once the call is given to shut down an air sector. All an ATC must do, if equipped with such a program, is to ensure that all planes keep their distance from another, and manage the use of the runway by those planes.

However, even this task, with the Clearance Program (below), is alleviated. Once the local ATC determines that it is safe, confirmed clearance is given to the pilot to land, and the job is done.

3.5 Clearance Program (CP)

The second program is the Clearance Program, or CP, which focuses in on individual airports and runway management. It was actually developed *before* ECP, but only as an experiment on how to manage runways; nevertheless ECP and CP operate nearly identically. CP has the capability of alleviating the task of managing arrivals at an airport from a human controller, leaving the human ATC the sole task of clearing (confirming) the planes to land. It begins by prompting the user for all Planes, their locations and names. The Clearance Program assumes the existence of only *one* Airport, and that all aircraft are seeking to land at this Airport. It will then attempt to schedule them all to land there.



The distinguishing point between ECP and CP is that the latter autonomously schedules planes to land at a particular airport whereas the former program autonomously directs planes to particular airports, but does not assume the task of landing the planes (see figure above). In simpler words, ECP says *where* and CP says *when*.

After taking all Plane locations, the Pilot class then calculates the distance of each Plane from the Airport. Using each Plane's speed, the program simulates the estimated arrival times (EAT) of every Plane, and seeks the Plane with the earliest EAT. This Plane shall get first priority to use the Airport's runway.

The Plane given first priority flies at its maximum speed to reach the Airport, and is given 45 seconds after its arrival time to clear the runway. Every Plane thereafter flies at an assigned, calculated speed by the program as to reach the airport at its prescribed time, in order of descending priority. For example, a Plane, say Plane A, whose speed translates into an EAT overlapping that of a higher priority Plane's EAT (Plane B) must slow down so that Plane B can land first, and that Plane A arrives at the exact moment when the runway is reserved specifically for Plane A (a time in which no other higher priority Planes are scheduled to land).

Because each Plane is flying at a unique speed, some faster, some slower than others, the program cannot simply give priority to those closest to the Airport. For example, consider a Plane, Plane C, flying 480 MPH with 35 miles left till reaching the Airport. Another Plane, Plane D, is at 640 MPH with 40 left. If Plane C was given clearance to land first, D would have to slow down more drastically than C so that it lands *after* Plane C. If Plane D landed first because of its lower EAT, Plane C would not experience such a drastic reduction in speed. In effect, by prioritizing planes by their EAT and not distance, the program enhances the efficiency of scheduling air traffic. The figure above shows the environment that the programs work in.

3.6 Multi-airport Clearance Program (MCP)

The MCP is really a second version of CP. The two programs are nearly identical except for the fact that MCP assumes a more flexible role of clearing aircraft, by scheduling the use of multiple airports at once. It was created to experiment upon the capabilities of CP when applied to several airports at once. MCP was rather short lived, however, because of yet another improvement that was realized.

MCP is of nominal use since it could only schedule the *landings* of planes in multiple airports. A program was needed which could schedule both departures and arrivals of airports whilst coordinating all traffic in between.

3.7 Total Autonomous Air Traffic Control Program (TAATCP)

TAATCP, demonstrates all the previous capabilities developed in this project in one program. It forms together all previous programs into one giant simulation and demonstration of automated air traffic. TAATCP models all airplanes, airports, scheduling, runway management and other functions of the programs hereinbefore enumerated (see diagram X.1, overleaf).

TAATCP was also slightly experimental, as it does not work, however, using CP or MCP's reservation process. A new process for reserving the runway was used.

There are two objects contained inside TAATCP: the "Plane", and the "Port" (airport). TAATCP and all its output, however, is heavily reliant on one class, which is the "Pilot" class. The Pilot stores all main equations and is involved in reserving the

runway at the destination for each aircraft at a time specifically appropriated to said aircraft.

The pilot is a class, but not an object as it is never instantiated. It works by taking a particular Plane's current location and its corresponding Port location and figuring the distance between the two. Contained in each Port object are two arrays: one array stores the departure list (array D) and the other, the arrival list (array A). Each element in the array represents units of time (in this case, seconds), and if the runway at the corresponding time is in use, the value is 1; if not, the value is by default 0.

The Pilot is responsible for searching array D at the Plane's current Port location, using its "Search" method. Using a loop, the Pilot will continue searching array D until the next 0 is found. A second, nested loop inside the first ensures that there are 45 consecutive elements in array D succeeding the 0 that are also zeros. This is to accommodate the assumed fact that at least 45 seconds are necessary for an aircraft to depart from an airport's runway. The time (index) of the first element whose value is zero is added by the Pilot to 45, giving the exact departure time for that aircraft.

The Pilot then searches array A of the Plane's destination, looking for an open element in the array. The next open element (the element whose value is zero) is the time in which the runway is not in use and the Plane can land. To reserve this time for the Plane, the Pilot changes the element's value to 1 so that no other Plane can use the runway at the same time. This process differentiates TAATCP from CP or MCP, as it does *not* look for estimated arrival times.

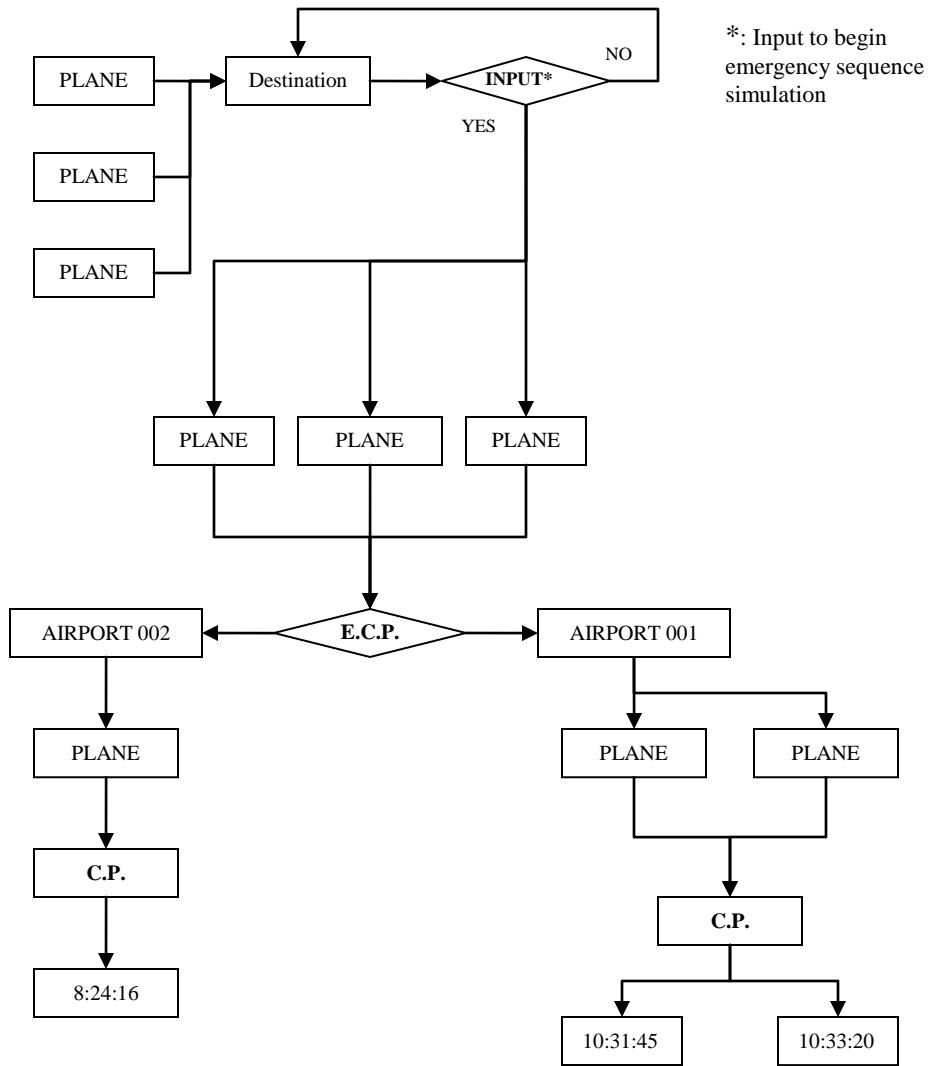


Diagram X.1: TAATCP general process flowchart

4.0 Results

R E S U L T S A N D D A T A

100.00		150.00		200.00		250.00		300.00		350.00		400.00		450.00		500.00		550.00		600.00		650.00		700.00		750.00		800.00		850.00		900.00		950.00		1000.00					
(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)	(X	Y)
101.94	115.50	102.91	123.25	103.88	131.00	104.84	138.75	105.81	146.50	106.78	154.25	107.75	162.00	108.72	169.75	109.69	177.50	110.66	185.25	111.63	193.00	112.59	200.75	113.56	208.50	114.53	100.00	115.50	224.00	116.47	231.75	117.44	239.50	118.41	247.25	119.38	255.00				
102.89	108.67	105.52	116.55	108.14	124.43	110.77	132.30	113.39	140.18	116.02	148.06	118.65	155.94	121.27	163.82	123.90	171.70	126.53	179.58	129.15	187.46	131.78	195.34	134.41	203.22	137.03	92.91	139.66	218.98	142.28	226.85	144.91	234.73	147.54	242.61	150.16	250.49				
101.45	100.67	108.67	104.05	115.90	107.42	123.13	110.79	130.35	114.16	137.58	117.54	144.81	120.91	152.03	124.28	159.26	127.65	166.49	131.03	173.71	134.40	180.94	137.77	188.17	141.15	195.40	93.93	202.62	147.89	209.85	151.26	217.08	154.64	224.30	158.01	231.53	161.38				
97.72	95.45	100.98	101.93	104.23	108.46	107.48	114.97	110.74	121.47	113.99	127.98	117.24	134.49	120.50	140.99	123.75	147.50	127.00	154.01	130.26	160.52	133.51	167.02	136.76	173.53	140.02	82.43	143.27	186.54	146.53	193.05	149.78	199.56	153.03	206.07	156.29	212.57				
88.46	101.15	95.67	100.15	102.89	99.71	110.10	98.99	117.31	98.27	124.53	97.55	131.74	96.83	138.96	96.12	146.17	95.38	153.39	94.66	160.60	93.94	167.82	93.22	175.03	92.50	182.24	102.60	189.46	91.05	196.67	90.33	203.89	89.61	211.10	88.89	218.32	88.17				
83.51	89.01	90.10	93.40	96.70	97.80	103.30	102.20	109.90	106.60	116.49	110.99	123.09	115.39	129.69	119.79	136.28	124.19	142.88	128.59	149.48	132.98	156.07	137.38	162.67	141.78	169.27	80.21	175.87	150.58	182.46	154.97	189.06	159.37	195.66	163.77	202.25	168.17				
85.03	77.55	89.44	84.15	93.84	90.76	98.24	97.36	102.64	103.96	107.04	110.56	111.44	117.17	115.85	123.77	120.25	130.37	124.65	136.97	129.05	143.58	133.45	150.18	137.85	156.78	142.26	64.35	146.66	169.99	151.06	176.59	155.46	183.19	159.86	189.79	164.26	196.39				
66.37	97.90	74.19	98.39	82.01	98.88	89.83	99.36	97.65	99.85	105.47	100.34	113.29	100.83	121.12	101.32	128.94	101.81	136.76	102.30	144.58	102.79	152.40	103.27	160.22	103.76	168.04	96.92	175.86	104.74	183.68	105.23	191.50	105.72	199.32	106.21	207.14	106.70				
65.64	74.23	72.25	79.18	78.85	84.14	85.46	89.10	92.07	94.05	98.68	99.01	105.29	103.96	111.89	108.92	118.50	113.88	125.11	118.83	131.72	123.79	138.33	128.75	144.94	133.70	151.54	64.32	158.15	143.61	164.76	148.57	171.37	153.53	177.98	158.48	184.59	163.44				
94.19	53.55	95.15	61.17	96.10	68.78	97.05	76.39	98.00	84.01	98.95	91.62	99.90	99.24	100.86	106.85	101.81	114.47	102.76	122.08	103.71	129.70	104.66	137.31	105.62	144.93	106.57	38.32	107.52	160.16	108.47	167.77	109.42	175.39	110.38	183.00	111.33	190.61				
148.03	484.24	147.05	476.37	146.06	468.49	145.08	460.61	144.09	452.73	143.11	444.85	142.12	436.97	141.14	429.10	140.15	421.22	139.17	413.34	138.18	405.46	137.20	397.58	136.21	389.70	135.23	500.00	134.24	373.95	133.26	366.07	132.27	358.19	131.29	350.31	130.30	342.44				
154.07	491.87	157.76	484.47	161.46	477.08	165.16	469.69	168.85	462.29	172.55	454.90	176.25	447.51	179.94	440.11	183.64	432.72	187.34	425.32	191.03	417.93	194.73	410.54	198.43	403.14	202.13	506.65	205.82	388.36	209.52	380.96	213.22	373.57	216.91	366.17	220.61	358.78				
150.48	498.41	152.89	490.46	155.30	482.51	157.71	474.57	160.12	466.62	162.52	458.67	164.93	450.72	167.34	442.77	169.75	434.83	172.16	426.88	174.57	418.93	176.97	410.98	179.38	403.03	181.79	514.31	184.20	387.14	186.61	379.19	189.03	371.24	191.43	363.29	193.83	355.35				
144.43	500.00	152.39	500.00	160.35	500.00	168.31	500.00	176.27	500.00	184.23	500.00	192.19	500.00	200.15	500.00	208.10	500.00	216.06	500.00	224.02	500.00	231.98	500.00	239.94	500.00	247.90	500.00	255.86	500.00	263.82	500.00	271.78	500.00	279.74	500.00	287.70	500.00				
144.60	511.47	147.98	504.30	151.35	497.13	154.72	489.97	158.09	482.80	161.47	475.63	164.84	468.47	168.21	461.30	171.58	454.14	174.96	446.97	178.33	439.80	181.70	432.64	185.07	425.47	188.45	525.80	191.82	411.14	195.19	403.97	198.56	396.80	201.93	389.64	205.31	382.47				
133.53	513.17	140.12	507.90	146.71	502.63	153.29	497.37	159.88	492.10	166.47	486.83	173.05	481.56	179.64	476.29	186.22	471.02	192.81	465.75	199.40	460.48	205.98	455.22	212.57	449.95	219.15	523.71	225.74	439.41	232.33	434.14	238.91	428.87	245.50	423.60	252.08	418.33				
122.65	494.53	130.69	496.14	138.74	497.25	146.78	499.36	154.83	500.97	162.82	502.57	170.92	504.16	178.96	505.79	187.01	507.40	195.05	509.01	203.10	510.62	211.14	512.23	219.19	513.84	227.23	491.31	235.28	517.06	243.32	510.66	251.37	520.27	259.41	521.88	267.34	523.49				
126.47	525.21	131.94	519.35	137.41	513.48	142.89	507.62	148.36	501.76	153.83	495.90	159.30	490.03	164.77	484.17	170.25	478.31	175.72	472.45	181.19	466.58	186.66	460.72	192.13	454.86	197.60	536.93	203.08	443.13	208.55	437.27	214.02	431.41	219.49	425.54	224.96	419.68				
108.65	511.82	116.60	509.54	124.55	507.27	132.50	505.00	140.46	502.73	148.41	500.45	156.36	498.18	164.31	495.91	172.27	493.64	180.22	491.37	188.17	489.09	196.12	486.82	204.08	484.55	212.03	516.36	219.98	480.01	227.93	477.73	235.89	475.46	243.84	473.19	251.79	470.92				
155.47	543.73	154.57	536.56	153.67	529.39	152.78	522.22	151.88	515.05	150.99	507.89	150.09	500.72	149.19	493.55	148.30	486.38	147.40	479.21	146.51	472.04	145.61	464.87	144.71	457.70	143.82	558.07	142.92	443.37	142.02	436.20	141.13	429.03	140.23	421.86	139.34	414.69				
195.26	385.78	192.89	378.66	190.52	371.55	188.15	364.44	185.78	357.33	183.40	350.21	181.03	343.10	178.66	335.99	176.29	328.88	173.92	321.77	171.55	314.65	169.18	307.54	166.81	300.43	164.44	400.00	162.07	286.21	159.70	279.09	157.33	271.98	154.96	264.87	152.59	257.76				
196.07	407.87	192.49	415.02	188.91	422.17	185.34	429.33	181.76	436.48	178.18	443.63	174.61	450.78	171.03	457.94	167.46	465.09	163.88	472.24	160.30	479.39	156.73	486.55	153.15	493.70	149.57	393.56	146.00	508.01	142.42	515.16	138.84	522.31	135.27	529.46	131.69	536.62				
200.35	398.39	202.11	390.31	203.86	382.24	205.62	374.16	207.37	366.09	209.13	358.02	210.88	349.94	212.64	341.87	214.39	333.79	216.15	325.72	217.90	317.65	219.66	309.57	221.41	301.50	223.17	414.53	224.92	285.35	226.68	277.28	228.43	269.20	230.19	261.13	231.94	253.05				
195.93	395.93	201.74	401.74	207.56	407.56	213.37	413.37	219.19	419.19	225.00	425.00	230.81	430.81	236.63	436.63	242.44	442.44	248.26	448.26	254.07	454.07	259.89	459.89	265.70	465.70	271.51	384.30	277.33	477.33	283.14	483.14	288.96	488.96	294.77	494.77	300.58	500.58				
194.90	411.06	198.09	404.15	201.28	397.24	204.47	390.33	207.65	383.42	210.84	376.51	214.03	369.59	217.22	362.68	220.41	355.77	223.60	348.86	226.79	341.95	229.98	335.04	233.16	328.13	236.36	424.88	239.55	314.31	242.74	307.40	245.93	300.49	249.12	293.58	286.67					
182.08	408.96	189.25	405.38	196.42	401.79	203.58	398.21	210.75	394.62	217.92	391.04	225.08	387.46	232.25	383.87	239.42	380.29	246.58	376.71	253.75	373.12	260.92	369.54	268.08	365.96	275.25	416.13	282.42	358.79	289.58	355.21	296.75	351.62	303.92	348.04	311.08	344.46				
177.70	383.28	184.26	388.20	190.82	393.11	197.38	398.03	203.93	402.95	210.49	407.87	217.05	412.79	223.61	417.71	230.16	422.62	236.72	427.54	243.28	432.46	249.84	437.38	256.39	442.30	262.95	373.44	269.51	452.13	276.07	457.05	282.62	461.97	289.18	466.89	295.74	471.80				
173.86	423.96	179.94	418.39	186.02	412.82	192.10	407.24	198.18	401.67	204.26	396.10	210.34	390.53	216.41	384.95	222.49	379.38	228.57	373.81	234.65	368.23	240.73	362.66	246.81	357.09	252.89	435.11	258.97	345.94	265.05	340.37	271.13	334.80	277.21	329.22	283.29	32				

346.24	82.98	342.83	90.24	339.41	97.50	336.00	104.76	332.58	112.01	329.17	119.27	325.75	126.53	322.33	133.79	318.92	141.05	315.50	148.30	312.09	155.56	308.67	162.82	305.26	170.08	301.84	68.47	298.43	184.59	295.01	191.85	291.60	199.11	288.18	206.37	284.77	213.62	
349.37	76.35	346.25	83.13	343.12	89.90	339.99	96.68	336.87	103.45	333.74	110.23	330.61	117.00	327.49	123.78	324.36	130.55	321.23	137.33	318.11	144.10	314.98	150.88	311.85	157.65	308.73	62.81	305.60	171.20	302.47	177.97	299.35	184.75	296.22	191.52	293.09	198.30	
354.02	71.18	348.28	76.64	342.53	82.09	336.79	87.55	331.04	93.01	325.30	98.46	319.56	103.92	313.81	109.38	308.07	114.84	302.32	120.29	296.58	125.75	290.84	131.21	285.09	136.66	279.35	60.27	273.60	147.58	267.86	153.03	262.12	158.49	256.37	163.95	250.63	169.40	
351.47	62.53	350.55	70.33	349.63	78.12	348.72	85.91	347.80	93.70	346.88	101.49	345.97	109.28	345.05	117.07	344.13	124.87	343.22	132.66	342.30	140.45	341.38	148.24	340.47	156.03	339.55	46.95	338.63	171.61	337.72	179.41	336.80	187.20	335.88	194.99	334.97	202.78	
345.73	55.80	347.44	63.48	349.15	71.16	350.85	78.84	352.56	86.52	354.27	94.20	355.97	101.88	357.68	109.56	359.39	117.24	361.09	124.91	362.80	132.59	364.51	140.27	366.21	147.95	367.92	40.45	369.62	163.31	371.33	170.99	373.04	178.67	374.74	186.35	376.45	194.03	
347.23	48.67	348.04	64.48	348.86	64.16	349.67	71.90	350.49	79.65	351.30	87.39	352.12	95.13	352.93	102.88	353.75	110.62	354.56	118.37	355.38	126.11	356.20	133.85	357.01	141.60	357.83	33.18	358.64	157.09	359.46	160.80	360.27	171.57	361.09	180.32	361.90	188.06	
316.13	63.71	324.01	66.34	331.88	68.96	339.76	71.59	347.64	74.21	355.51	76.84	363.39	79.46	371.27	82.09	379.14	84.71	387.02	87.34	394.90	89.97	402.77	92.59	410.65	95.22	418.52	58.46	426.40	100.47	434.28	103.09	442.15	105.72	450.03	108.34	457.91	110.97	
332.45	36.97	335.82	44.28	339.20	51.60	342.57	58.91	345.95	66.22	349.32	73.54	352.70	80.85	356.08	88.16	359.45	95.48	362.83	102.79	366.20	110.10	369.58	117.42	372.95	124.73	376.33	22.35	379.70	139.36	383.08	146.67	386.45	153.98	389.83	161.30	393.20	168.61	
301.74	58.91	309.65	61.55	317.56	64.19	325.47	66.82	333.39	69.46	341.30	72.10	349.21	74.74	357.12	77.37	365.03	80.01	372.94	82.65	380.86	85.29	388.77	87.92	396.68	90.56	404.59	53.64	412.50	95.83	420.42	98.47	428.33	101.11	436.24	103.75	444.15	106.38	
386.51	291.01	379.77	286.51	373.02	282.02	366.28	277.52	359.53	273.02	352.79	268.53	346.05	264.03	339.30	259.53	332.56	255.04	325.81	250.54	319.07	246.05	312.32	241.55	305.58	237.05	298.84	300.00	292.09	228.06	285.35	223.56	278.60	219.07	271.86	214.57	265.11	210.08	
393.11	305.51	386.85	310.52	380.59	315.53	374.33	320.54	368.07	325.55	361.80	330.56	355.54	335.57	349.28	340.58	343.02	345.59	336.76	350.59	330.50	355.60	324.23	360.61	317.97	365.62	311.71	295.49	305.45	375.64	299.19	380.65	292.93	385.66	286.66	390.67	280.40	395.68	
398.67	300.66	392.05	303.98	385.42	307.29	378.80	310.60	372.17	313.92	365.54	317.23	358.92	320.54	352.29	323.85	345.67	327.17	339.04	330.48	332.41	333.79	325.79	337.11	319.16	340.42	312.53	294.04	305.91	347.05	299.28	350.36	292.66	353.67	286.03	356.99	279.40	360.30	
404.12	303.57	398.23	298.47	392.35	293.37	386.46	288.26	380.57	283.16	374.68	278.06	368.79	272.95	362.90	267.85	357.02	262.75	351.13	257.64	345.24	252.54	339.35	247.44	333.46	242.34	327.58	313.78	321.69	232.13	315.80	227.03	309.91	221.92	304.02	216.82	298.14	211.72	
405.47	289.06	402.05	295.90	388.63	302.74	395.21	309.58	391.79	316.42	388.37	323.26	389.94	330.10	381.53	336.94	378.11	343.78	374.69	350.61	371.27	357.46	367.85	364.30	364.03	371.14	361.01	275.37	357.59	384.82	354.17	391.66	350.75	398.50	347.33	345.94	340.34	343.91	412.18
404.16	318.71	402.50	311.23	400.83	303.74	399.17	296.26	397.50	288.77	395.84	281.29	394.18	273.80	392.51	266.32	390.85	258.83	389.19	251.35	387.52	243.86	385.86	236.37	384.20	228.89	382.53	333.68	380.87	213.92	379.21	206.43	377.54	198.95	375.88	191.46	374.22	183.98	
400.00	274.76	400.00	282.18	400.00	289.61	400.00	297.03	400.00	304.45	400.00	311.88	400.00	319.30	400.00	326.73	400.00	334.15	400.00	341.58	400.00	349.00	400.00	356.43	400.00	363.85	400.00	259.91	400.00	378.70	400.00	386.12	400.00	393.55	400.00	400.97	400.00	408.40	
381.87	331.73	386.09	324.35	390.30	316.97	394.52	309.59	398.74	302.21	402.95	294.84	407.17	287.46	411.38	280.08	415.60	272.70	419.82	265.32	424.03	257.95	428.25	250.57	432.46	243.19	436.68	346.48	440.89	228.43	445.11	221.06	449.33	213.68	453.54	206.30	457.76	198.92	
373.26	273.26	378.40	278.40	383.54	283.54	388.69	288.69	393.83	293.83	398.97	298.97	404.11	304.11	409.26	309.26	414.40	314.40	419.54	319.54	424.69	324.69	429.83	329.83	434.97	334.97	440.11	262.97	445.26	345.26	450.40	355.40	455.54	353.54	460.69	360.69	465.83	365.83	
438.13	333.04	431.88	327.63	425.63	322.21	419.38	316.79	413.13	311.38	406.88	305.96	400.63	300.54	394.37	295.12	388.12	289.71	381.87	284.29	375.62	278.87	369.37	273.46	363.12	268.04	356.87	343.88	350.62	257.21	344.37	251.79	338.12	246.37	331.87	240.96	325.62	235.54	
390.61	535.92	385.92	528.88	381.22	521.84	376.53	514.80	371.84	507.76	367.14	500.72	362.45	493.67	357.76	486.63	353.06	479.59	348.37	472.55	343.67	465.51	338.98	458.47	334.29	451.43	329.59	450.00	324.90	437.35	320.21	430.31	315.51	423.27	310.82	416.23	306.12	409.19	
392.04	548.41	384.81	546.96	377.58	545.52	370.35	544.07	363.11	542.62	355.88	541.18	348.65	539.73	341.42	538.28	334.18	536.84	326.95	535.39	319.72	533.94	312.49	532.50	305.25	531.05	298.02	531.30	290.79	528.16	283.56	526.71	276.33	525.27	269.09	523.82	261.86	522.37	
398.71	549.03	392.25	544.18	388.78	539.34	379.32	534.49	372.86	529.64	366.50	524.80	359.94	519.95	353.47	515.10	347.01	510.26	340.95	505.41	334.09	500.57	327.63	495.72	321.16	490.87	314.70	558.37	308.24	481.18	301.78	476.33	295.31	471.89	285.46	466.64	281.39	461.79	
402.07	555.24	399.11	547.75	396.16	540.26	393.20	532.77	390.24	525.28	387.28	517.79	384.33	510.29	381.37	502.80	378.41	495.31	375.45	487.82	372.50	480.33	369.54	472.83	366.58	465.34	363.63	570.23	360.67	450.36	357.71	442.87	354.75	435.38	351.80	427.88	348.84	420.39	
410.54	555.27	403.95	551.98	397.36	548.68	390.77	545.39	384.18	542.09	377.60	538.80	371.01	535.50	364.42	532.21	357.83	528.91	351.24	525.62	344.65	522.32	338.06	519.03	331.47	515.73	324.88	561.86	318.29	509.14	311.70	505.85	305.11	502.55	298.52	499.26	291.93	495.97	
402.01	569.10	401.21	561.46	400.40	553.82	399.60	546.18	398.79	538.54	397.99	530.90	391.19	523.26	396.38	515.62	395.58	507.98	394.77	500.34	393.97	492.70	393.16	485.06	392.36	477.42	391.56	584.38	390.75	462.14	389.95	454.50	389.14	446.86	388.34	439.22	387.54	431.58	
400.00	575.86	400.00	568.26	400.00	560.65	400.00	553.04	400.00	545.44	400.00	537.83	400.00	530.22	400.00	522.62	400.00	515.00	400.00	507.40	400.00	499.80	400.00	492.19	400.00	484.59	400.00	591.07	400.00	469.37	400.00	461.77	400.00	454.16	400.00	446.55	400.00	438.95	
392.52	581.78	394.26	574.39	396.00	567.00	397.74	559.61	399.48	552.22	401.22	544.83	402.96	537.44	404.69	530.05	406.43	522.66	408.17	515.27	409.91	507.88	411.65	500.49	413.39	493.10	415.13	596.56	416.87	478.31	418.61	470.92	420.34	463.53	422.08	456.14	423.82	448.75	
376.88	584.68	381.33	578.01	385.77	571.34	390.22	564.67	394.67	558.00	399.11	551.33	403.56	544.67	408.00	538.00	412.45	531.33	416.89	524.66	421.34	517.99	425.78	511.32	430.23	504.66	434.68	598.01	439.12	491.32	443.57	484.65	448.01	477.98	452.46	471.31	456.90	464.65	
439.62	569.81	433.13	566.56	426.63	563.32	420.14	560.07	413.64	556.82	407.15	553.57	400.65	550.32	394.15	547.08	387.66	543.83	381.16	540.58	374.67	537.33	368.17	534.09	361.68	530.84	355.18	576.31	348.69	524.34	342.19	521.10	335.69	517.85	329.20	514.60	322.70	511.35	
485.40	124.09	478.10	123.63	470.80	123.17	463.49	122.72	456.19	122.26	448.89	121.81	441.59																										

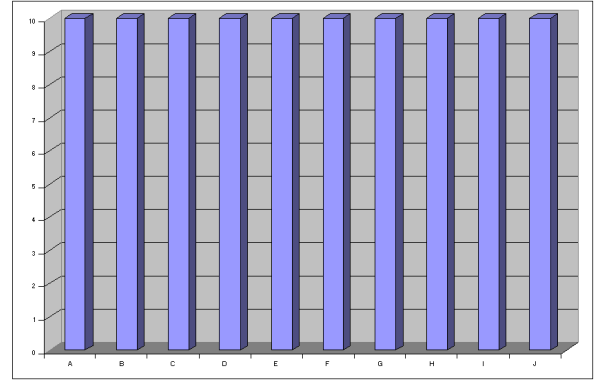
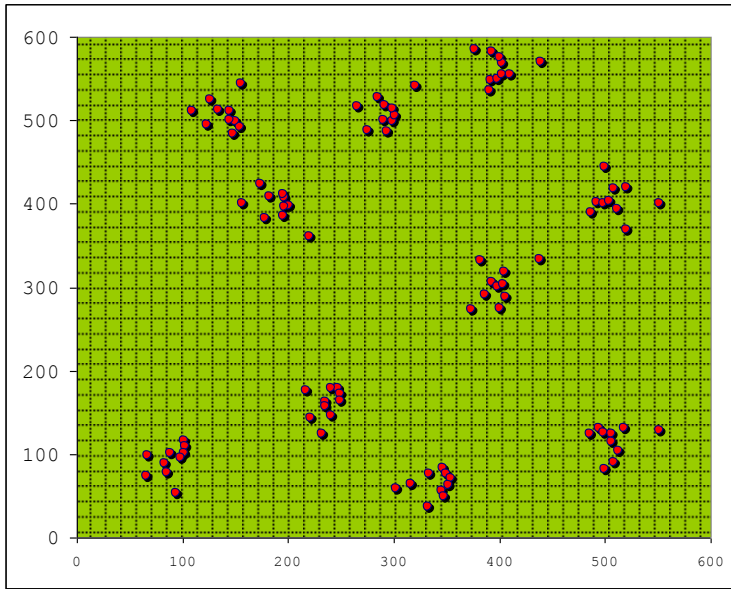


Figure X.1: Aircraft distribution and assigned emergency airports @ 100 seconds

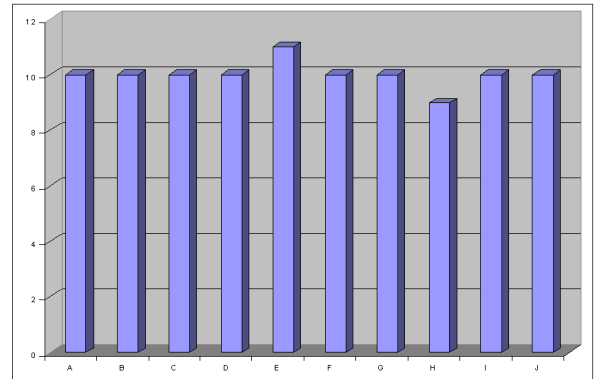
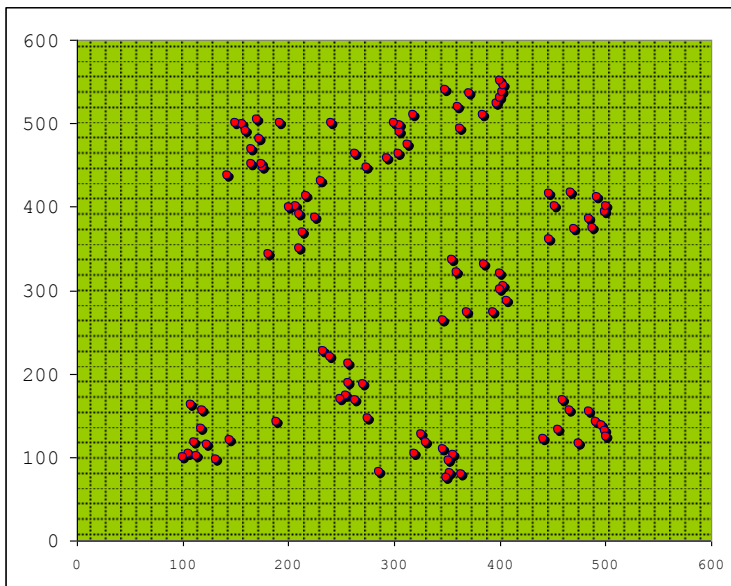


Figure X.2: Aircraft distribution and assigned emergency airports @ 400 seconds

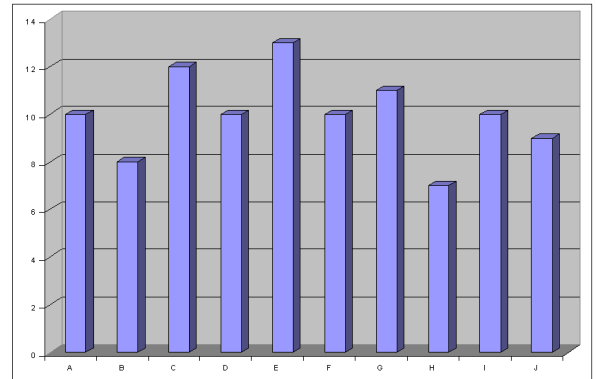
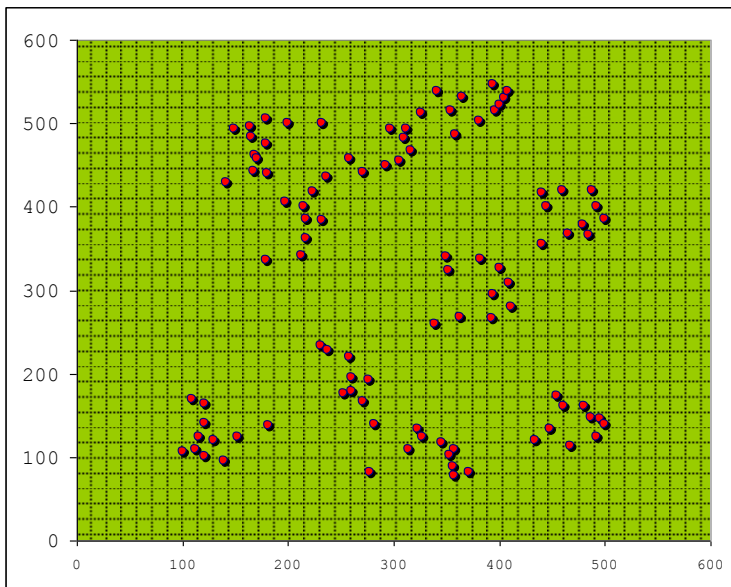


Figure X.3: Aircraft distribution and assigned emergency airports @ 450 seconds

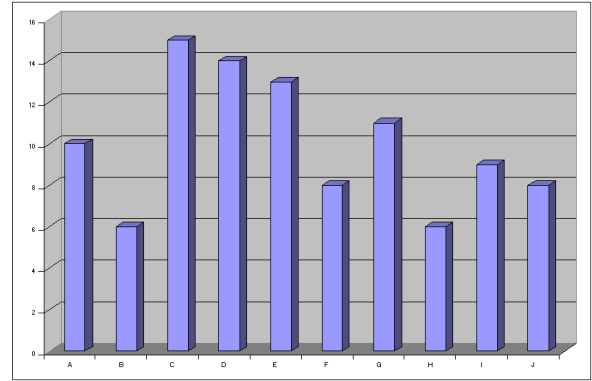
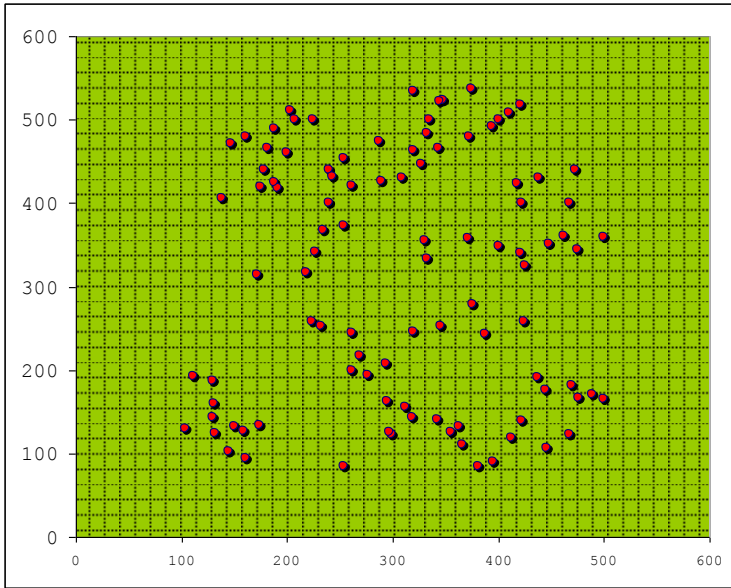


Figure X.5: Aircraft distribution and assigned emergency airports @ 600 seconds

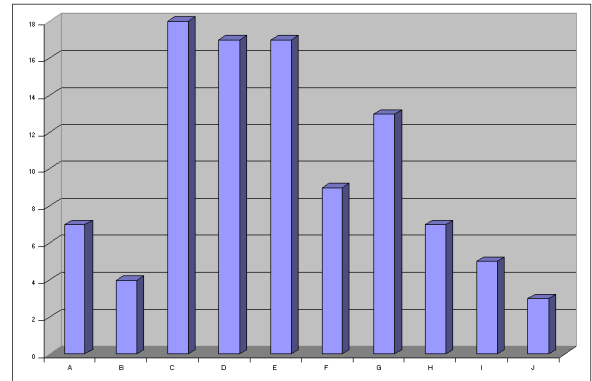
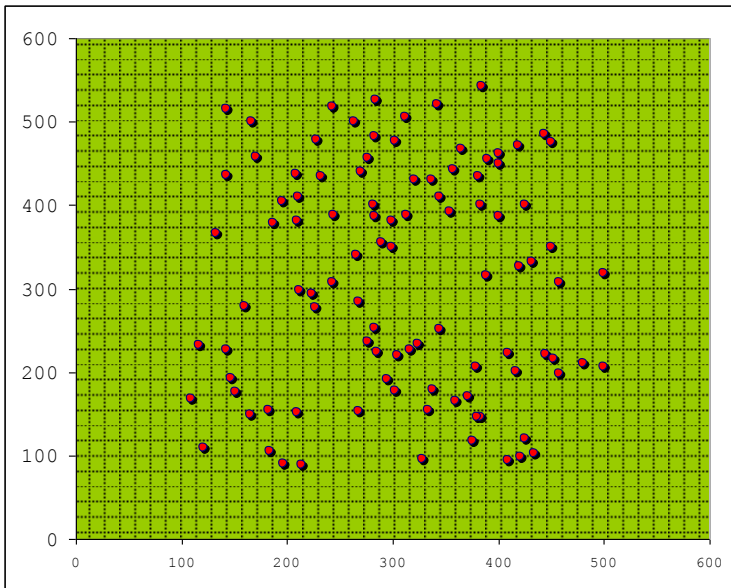


Figure X.6: Aircraft distribution and assigned emergency airports @ 600 seconds

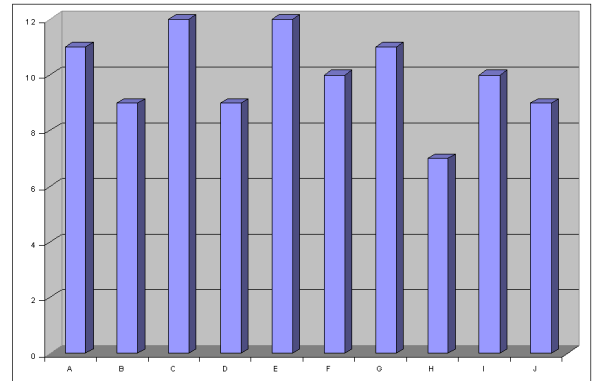
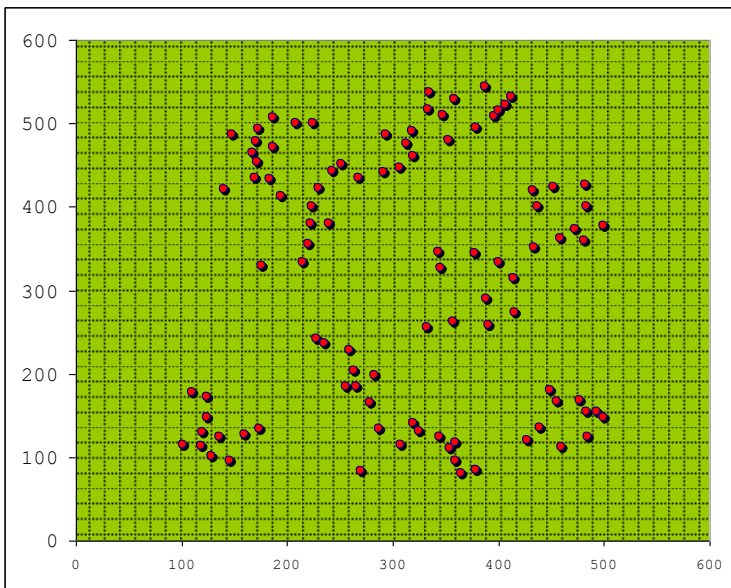


Figure X.4: Aircraft distribution and assigned emergency airports @ 500 seconds

Table X.2: ECP output data at 100 seconds. The yellow shaded areas are the designated emergency landing areas.

A	B	C	D	E	F	G	H	I	J	location	A	B	C	D	E	F	G	H	I	J
15.62	387.49	300.93	157.77	432.51	251.35	350.54	526.91	398.18	489.28	15.62	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.14	394.16	307.09	159.38	438.17	249.39	353.39	532.02	397.45	492.52	9.14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.59	402.27	315.13	163.93	445.97	249.88	358.98	539.47	399.30	498.44	1.59	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.09	407.92	321.27	169.55	452.31	253.10	364.99	545.89	403.36	504.56	5.09	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.60	403.57	318.98	175.60	451.47	262.85	369.59	546.37	412.23	508.60	11.60	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.82	416.34	332.10	185.15	464.53	266.86	380.38	559.18	418.05	519.79	19.82	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26.98	427.41	342.33	189.10	474.00	264.98	385.60	567.81	417.67	525.52	26.98	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.69	410.71	330.34	197.28	465.05	284.55	390.07	561.88	434.47	528.49	33.69	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42.95	434.05	352.39	207.75	486.01	284.36	403.45	581.51	437.32	542.95	42.95	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46.81	449.92	362.25	194.51	491.60	256.70	392.75	583.08	412.05	533.58	46.81	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
387.23	15.88	98.98	330.37	152.78	456.37	312.15	260.41	502.93	361.91	15.88	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
395.58	9.09	102.71	335.86	146.16	460.62	311.92	252.71	504.24	357.92	9.09	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
401.60	1.66	110.17	343.16	149.53	468.06	318.79	254.80	511.47	363.11	1.66	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
402.46	5.57	114.40	346.48	155.57	472.11	324.53	260.42	516.78	369.37	5.57	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
413.88	12.67	124.47	357.36	155.82	482.38	331.58	258.29	525.04	372.47	12.67	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
414.53	21.09	131.25	362.40	166.99	488.72	341.24	269.00	533.83	383.54	21.09	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
395.18	27.89	122.14	348.62	177.44	477.17	338.77	282.85	528.15	389.01	27.89	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
426.03	34.48	145.20	376.08	175.35	502.65	354.31	274.65	547.44	393.96	34.48	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
411.91	43.01	144.39	369.89	191.72	499.06	360.21	293.84	550.26	407.01	43.01	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
447.18	44.07	150.47	385.50	151.00	507.50	345.26	244.61	542.25	373.31	44.07	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
301.23	122.86	14.99	222.61	154.98	347.17	221.98	262.47	401.09	305.07	14.99	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
322.51	103.01	8.80	243.91	138.89	366.74	230.70	248.58	415.20	304.04	8.80	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
314.81	113.41	1.65	233.72	142.32	356.33	222.57	250.69	405.62	299.65	1.65	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
311.09	113.75	5.76	232.31	147.18	356.00	225.49	255.70	407.26	304.10	5.76	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
325.21	99.63	12.18	247.27	137.69	370.12	233.24	247.73	418.23	305.30	12.18	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
319.68	96.53	20.03	248.42	148.97	373.80	243.64	259.58	426.27	318.04	20.03	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
293.74	119.96	27.87	225.20	169.06	353.16	237.38	277.87	413.02	322.73	27.87	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
332.28	79.69	35.46	265.13	147.29	390.90	257.89	258.89	442.43	327.02	35.46	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
305.31	100.23	43.29	248.20	174.73	378.13	263.04	285.81	439.85	343.29	43.29	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
286.49	156.31	44.50	192.56	161.12	313.47	189.89	261.65	365.75	282.91	44.50	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
148.73	347.60	239.64	16.80	343.36	144.92	214.70	420.89	267.92	355.76	16.80	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
167.07	335.71	226.29	9.11	325.57	145.92	194.96	401.43	258.29	335.85	9.11	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
165.90	343.16	233.71	1.66	332.21	139.31	197.70	407.15	254.66	338.87	1.66	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
162.47	349.93	240.66	5.65	339.41	134.78	202.82	414.04	253.92	344.13	5.65	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
161.27	333.68	224.84	12.88	326.56	150.81	200.15	403.89	264.87	340.81	12.88	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
146.96	353.17	245.27	19.41	348.76	141.14	217.90	425.84	266.63	359.10	19.41	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
147.61	365.71	257.55	26.19	359.34	130.41	222.05	434.73	260.44	363.46	26.19	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
139.11	330.72	224.58	34.04	334.56	167.43	221.46	416.57	288.06	361.30	34.04	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
128.69	363.58	257.42	39.22	365.17	145.91	237.70	444.16	279.47	378.92	39.22	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
134.04	384.75	277.78	49.39	382.07	127.92	243.36	457.93	268.14	384.76	49.39	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
432.55	144.04	127.59	319.85	14.67	415.75	215.13	123.85	416.68	224.09	14.67	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
443.19	140.82	135.09	332.52	9.18	429.10	227.86	120.08	429.40	231.85	9.18	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
445.63	148.82	139.75	332.42	1.67	426.90	223.08	113.39	424.52	224.14	1.67	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
452.58	150.95	145.99	339.40	5.63	433.37	228.23	108.66	429.53	225.41	5.63	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
458.50	149.03	150.12	346.74	13.43	441.36	236.29	107.98	437.54	231.25	13.43	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
459.50	142.18	148.97	350.31	20.01	446.81	243.62	113.58	445.01	239.92	20.01	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
425.47	125.94	115.59	318.67	27.58	419.37	225.30	139.38	426.62	241.17	27.58	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
466.08	138.04	153.52	359.42	31.38	457.30	254.98	116.92	456.38	249.86	31.38	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

Table X.2 (cont.) : ECP output data at 100 seconds. The yellow shaded areas are the designated emergency landing areas.

448.88	116.70	134.30	347.64	38.67	450.31	255.60	138.51	457.09	262.28	38.67	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
493.36	175.55	185.77	377.93	46.14	467.19	253.99	79.84	453.27	228.32	46.14	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
235.12	461.63	350.04	125.59	424.76	16.12	232.95	477.98	172.95	363.53	16.12	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
246.83	460.88	349.12	129.75	419.57	8.82	223.58	470.10	159.39	352.34	8.82	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
250.49	468.22	356.45	136.55	426.51	1.49	229.30	476.34	158.29	356.98	1.49	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
255.65	474.88	363.10	143.48	432.21	5.55	233.39	481.02	155.58	359.77	5.55	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
254.24	481.63	369.90	147.80	440.48	12.55	242.38	489.88	161.13	368.71	12.55	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
249.68	485.41	373.78	149.02	446.55	19.67	250.15	497.17	169.08	377.19	19.67	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
252.50	492.54	380.93	155.48	453.79	26.47	256.81	504.10	170.78	383.11	26.47	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
219.16	466.85	355.78	125.18	436.59	35.70	250.73	493.47	193.81	383.27	35.70	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
240.84	497.68	386.44	156.51	464.16	41.88	271.56	517.46	189.27	399.83	41.88	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
205.88	466.46	355.94	122.54	441.09	50.87	260.34	500.82	208.99	394.52	50.87	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
344.34	315.62	216.02	182.42	226.19	219.07	16.21	259.34	201.09	157.35	16.21	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
357.98	311.34	214.99	197.09	215.63	234.51	8.82	244.59	209.78	142.67	8.82	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
359.82	318.71	222.13	197.93	222.42	230.85	1.48	249.34	202.79	141.90	1.48	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
365.97	321.19	225.75	203.95	222.32	234.89	5.45	246.46	202.68	135.98	5.45	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
359.24	331.31	233.51	195.82	235.84	221.13	12.24	261.00	189.34	145.75	12.24	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
374.63	312.19	219.75	214.20	209.08	249.66	19.17	231.32	216.13	125.67	19.17	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
347.19	336.50	235.98	182.96	246.44	205.92	25.24	275.24	180.08	160.27	25.24	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
364.89	286.50	194.26	208.67	187.13	258.70	36.54	219.03	238.10	136.44	36.54	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
323.55	318.21	214.67	160.79	238.28	199.62	37.82	278.03	195.05	179.24	37.82	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
410.66	333.00	247.36	248.95	216.69	272.68	50.45	220.28	217.05	91.17	50.45	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
523.91	243.28	234.11	392.01	97.47	462.70	236.11	16.92	425.23	174.47	16.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
535.13	246.84	242.71	404.19	104.00	475.27	248.54	8.11	436.95	183.52	8.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
539.31	253.49	248.38	407.16	110.21	476.53	249.03	1.62	435.96	180.19	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
546.35	258.05	254.82	414.17	116.06	483.06	255.25	5.64	441.25	183.55	5.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
551.10	266.34	261.61	417.38	123.59	484.07	255.49	11.79	439.47	179.20	11.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
557.91	261.31	263.44	427.07	123.21	496.83	269.11	19.20	454.78	195.44	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
562.53	261.26	266.32	432.69	125.52	503.35	275.86	25.86	461.82	202.30	25.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
563.63	255.94	264.78	435.75	123.48	508.56	281.88	32.65	469.25	211.17	32.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
558.19	242.17	255.72	433.65	114.37	510.38	285.61	41.67	475.88	221.95	41.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
579.71	297.92	293.69	442.50	156.10	502.86	272.71	44.30	448.89	180.23	44.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
386.15	503.79	396.96	239.83	419.15	144.02	195.55	434.39	14.63	276.30	14.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
395.08	503.88	397.92	246.81	416.24	154.56	192.73	428.75	9.08	268.44	9.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
399.75	511.48	405.48	252.76	423.60	157.40	200.14	435.38	1.49	274.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
406.56	517.73	412.01	259.97	428.71	163.36	205.43	439.01	5.95	276.12	5.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
406.00	524.78	418.52	261.77	437.22	160.61	213.78	448.43	12.22	285.84	12.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
419.33	521.22	416.61	270.99	428.62	177.27	206.17	435.29	19.16	269.55	19.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
412.33	537.14	430.67	270.62	449.81	164.79	226.37	460.45	24.82	296.80	24.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
408.24	544.03	436.75	270.10	459.38	158.88	235.79	472.08	35.48	309.64	35.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
400.41	545.23	437.23	265.06	463.44	150.16	239.90	478.63	43.07	318.07	43.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
452.16	547.04	444.15	304.16	448.75	208.19	228.91	448.10	51.38	276.59	51.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
483.53	354.29	286.99	323.32	216.74	343.54	125.14	181.94	265.44	16.47	16.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
494.91	355.51	291.84	335.35	215.27	356.74	137.50	173.89	277.45	8.49	8.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
498.77	362.53	298.47	338.58	222.24	357.31	140.34	179.43	275.00	1.53	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
505.32	366.82	303.95	345.05	225.56	362.88	146.76	179.53	278.65	5.34	5.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
506.06	377.02	311.89	344.63	236.84	357.78	146.15	191.88	269.34	13.23	13.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
517.91	367.66	309.03	358.48	223.89	378.19	160.57	170.56	293.51	20.25	20.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
527.87	378.47	320.51	367.82	234.03	384.47	169.56	176.92	295.56	28.14	28.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

499.31	392.49	321.66	335.99	255.90	340.30	138.95	216.74	245.50	36.46	36.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
527.29	354.52	303.15	370.59	207.81	397.92	174.96	146.04	318.56	43.56	43.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
542.10	413.79	351.53	379.23	270.68	382.41	181.55	213.21	279.79	51.53	51.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
										SUM	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

Table X.3 : ECP output data at 850 seconds. The yellow shaded areas are the designated emergency landing areas.

A	B	C	D	E	F	G	H	I	J	location	A	B	C	D	E	F	G	H	I	J
132.78	270.34	187.84	147.12	325.02	281.26	291.63	426.23	398.11	418.81	132.78	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
133.72	273.25	182.51	121.80	315.41	257.30	267.89	413.33	371.93	397.42	121.80	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
121.22	353.84	248.93	44.31	360.20	159.56	241.41	441.76	291.34	382.18	44.31	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
104.03	306.97	213.75	106.01	343.18	235.24	275.11	437.79	359.97	409.60	104.03	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
97.16	412.32	309.69	95.87	422.50	154.09	292.07	502.63	305.30	433.48	95.87	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
99.11	346.55	245.65	69.19	364.50	185.65	261.45	450.96	318.95	401.08	69.19	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
92.05	323.41	228.71	99.16	356.06	223.38	277.85	448.79	352.73	414.34	92.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
83.84	396.20	295.22	92.70	411.55	169.04	291.08	494.59	316.94	432.37	83.84	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80.95	351.74	253.89	87.89	376.55	199.31	279.76	465.28	336.07	419.05	80.95	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68.30	334.81	249.62	141.55	383.48	258.73	320.12	480.72	393.86	455.22	68.30	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
268.14	134.97	74.87	228.19	213.87	362.90	274.80	324.01	438.88	368.31	74.87	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
301.55	133.09	21.28	214.81	149.52	336.67	206.97	254.67	387.16	291.10	21.28	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
292.32	126.23	24.75	218.58	165.69	345.30	227.61	273.33	403.52	314.08	24.75	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
432.25	113.82	118.63	330.29	36.18	433.65	241.96	145.07	443.18	256.48	36.18	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
318.53	106.13	6.24	240.31	142.15	363.58	229.69	251.54	413.20	304.84	6.24	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
359.39	105.43	47.02	264.73	94.43	377.93	214.73	203.81	408.92	269.84	47.02	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
442.52	95.17	126.33	348.73	59.67	456.31	269.00	159.78	469.95	282.78	59.67	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
354.31	85.81	38.24	270.47	110.90	388.91	235.58	222.18	427.15	293.83	38.24	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
398.81	81.05	82.60	308.52	75.43	420.83	247.38	186.63	445.47	282.95	75.43	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
338.81	64.30	68.35	287.26	170.37	416.79	291.72	281.96	474.33	359.80	64.30	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
188.78	221.12	127.45	141.62	261.70	279.05	241.21	362.13	373.56	361.14	127.45	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
417.32	16.95	128.75	361.53	158.31	486.65	335.62	259.92	529.23	375.66	16.95	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
217.89	235.55	125.59	109.78	234.48	236.90	174.80	323.14	312.88	299.61	109.78	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
424.66	134.20	117.58	314.89	23.84	413.58	217.25	134.63	418.68	232.25	23.84	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
251.77	213.76	101.98	137.59	200.93	255.96	157.44	289.11	315.36	273.42	101.98	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
317.92	201.12	100.16	189.39	145.17	286.65	123.45	223.91	311.88	215.13	100.16	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
398.10	133.18	95.08	288.23	49.17	389.14	200.06	154.92	400.50	231.09	49.17	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
291.58	196.77	88.25	171.03	163.41	278.64	140.86	249.31	318.72	242.40	88.25	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
350.67	165.27	81.58	232.16	101.68	332.12	154.99	191.11	351.19	218.42	81.58	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
365.04	46.87	64.93	298.72	135.68	422.85	278.29	246.80	468.19	334.12	46.87	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.70	391.51	301.07	142.83	429.66	232.03	338.13	521.57	379.74	477.81	22.70	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
226.81	211.49	103.02	133.33	220.97	262.26	188.68	315.12	336.33	306.29	103.02	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
229.44	218.98	108.89	126.48	220.25	252.75	176.98	311.49	324.16	296.61	108.89	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
248.73	245.72	134.04	115.38	218.39	224.84	133.67	297.20	281.89	259.99	115.38	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
228.25	441.83	330.20	107.87	405.28	30.06	216.54	459.93	174.27	349.44	30.06	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
260.21	317.86	207.16	97.03	267.47	160.78	101.46	325.61	207.36	242.73	97.03	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
238.47	280.34	168.62	89.36	247.48	190.37	126.22	319.17	252.16	262.19	89.36	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
239.77	390.71	278.96	84.72	346.62	81.70	159.58	400.59	169.30	296.30	81.70	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
237.04	319.71	208.05	73.91	279.99	152.04	124.63	343.53	217.47	265.79	73.91	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
223.42	291.79	180.01	72.07	264.02	177.94	138.66	336.47	250.04	276.64	72.07	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
322.55	146.00	45.72	218.57	124.67	330.85	179.14	224.37	367.20	256.01	45.72	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
405.35	15.67	105.73	340.61	134.33	463.25	308.08	239.61	502.40	348.97	15.67	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
329.25	108.10	14.48	243.51	126.94	363.21	219.46	235.67	406.60	289.94	14.48	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
339.59	174.85	83.90	218.69	115.08	318.40	145.53	201.42	339.75	217.68	83.90	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
358.51	197.74	113.75	227.21	112.51	315.42	123.83	183.58	322.83	187.22	112.51	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
395.36	214.33	145.13	258.49	100.07	335.54	123.54	150.05	324.98	155.60	100.07	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
525.53	237.91	232.60	395.53	94.09	468.33	242.60	17.71	432.87	183.32	17.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

407.03	199.06	140.24	275.13	78.09	356.34	145.56	134.68	346.91	166.19	78.09	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
453.11	217.64	178.41	318.93	72.88	392.70	170.99	89.63	367.99	150.72	72.88	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
379.89	134.16	80.42	270.52	67.32	373.48	190.97	170.51	389.92	233.52	67.32	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
114.21	416.26	311.66	89.12	420.33	137.04	281.79	497.58	288.66	423.02	89.12	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
215.56	340.56	228.81	50.03	308.19	129.14	150.73	373.22	215.61	292.14	50.03	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
216.97	356.30	244.53	53.08	322.04	113.41	156.21	384.60	204.51	297.17	53.08	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
176.04	366.44	256.12	24.63	348.45	113.30	197.64	418.38	233.83	338.94	24.63	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
250.63	371.51	260.05	88.22	322.80	105.13	135.73	375.79	171.16	273.86	88.22	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
280.46	396.53	286.01	121.34	336.65	98.33	132.16	380.09	136.64	262.68	98.33	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
267.43	395.24	284.13	109.58	340.40	90.33	141.12	387.30	146.08	273.97	90.33	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
334.29	488.21	378.21	196.05	419.01	88.84	199.87	448.22	69.28	304.09	69.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
286.90	423.28	312.56	135.11	362.97	78.93	154.26	403.69	118.91	279.01	78.93	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
320.42	484.10	373.50	184.82	419.20	74.22	202.56	451.99	83.89	311.85	74.22	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
222.76	307.79	195.99	64.18	276.82	162.02	137.80	345.98	236.20	277.86	64.18	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
344.15	191.05	101.06	216.32	119.35	309.85	129.10	197.09	325.09	201.74	101.06	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
319.99	211.37	111.00	186.97	149.64	279.99	112.61	223.61	301.79	206.77	111.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250.41	319.38	208.16	87.07	273.43	155.83	111.42	333.77	210.57	252.68	87.07	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
386.87	231.13	154.39	244.92	121.12	316.69	102.48	164.84	303.93	146.07	102.48	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
298.81	372.45	263.79	134.25	304.06	134.64	95.85	344.19	145.68	228.16	95.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
414.57	274.71	200.48	263.08	151.55	315.12	86.12	163.88	279.62	100.96	86.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
365.73	406.08	303.48	201.68	314.43	174.29	90.92	332.02	110.63	187.17	90.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
430.67	335.59	255.26	269.64	212.13	293.13	71.28	205.87	230.79	70.15	70.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
287.68	315.26	206.91	124.88	252.14	176.88	73.61	303.35	200.74	214.91	73.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
396.98	183.92	123.97	269.61	72.56	356.56	152.80	143.85	354.32	182.33	72.56	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
464.52	136.20	151.78	358.29	31.37	456.57	254.87	118.75	456.31	250.80	31.37	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
427.01	153.61	127.22	310.68	23.73	404.22	201.84	122.78	403.39	212.41	23.73	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
428.92	215.43	163.43	293.36	81.21	367.95	148.99	115.18	348.26	148.61	81.21	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
457.74	161.80	153.89	341.47	13.08	432.55	223.99	98.72	424.86	216.01	13.08	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
457.98	244.22	197.61	317.06	100.80	381.60	154.83	96.02	347.40	122.81	96.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
469.97	252.91	209.32	328.07	107.06	389.99	161.77	88.23	351.30	117.54	88.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
488.97	270.18	229.82	344.94	122.12	401.82	171.93	81.23	355.37	107.96	81.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
515.75	293.97	257.86	369.42	144.38	420.20	189.72	78.54	364.05	101.74	78.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
485.77	193.34	186.77	363.00	47.17	446.16	228.53	64.63	426.37	198.92	47.17	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
276.42	444.44	333.00	136.49	390.21	49.54	184.34	433.43	124.36	308.80	49.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
332.59	380.11	274.72	167.66	298.63	158.64	78.44	328.02	132.85	199.65	78.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
332.55	400.45	294.02	169.66	320.68	142.87	100.09	349.08	112.95	215.42	100.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
284.22	421.92	311.11	132.49	362.50	77.72	154.72	403.95	121.53	280.27	77.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
370.24	414.88	312.27	206.85	322.62	173.38	99.26	338.65	102.38	190.84	99.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
309.17	481.05	370.05	176.04	419.73	62.32	205.50	455.38	95.79	318.53	62.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
371.30	430.99	327.35	209.94	340.37	164.07	116.89	356.24	84.67	205.82	84.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
395.65	438.54	337.68	233.40	340.42	187.94	119.58	348.33	88.28	190.15	88.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
413.85	456.99	357.17	252.60	355.44	199.26	137.13	358.08	81.17	193.83	81.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
325.82	468.91	359.06	182.09	399.78	87.79	181.43	430.41	74.96	289.51	74.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
359.98	300.83	205.90	200.88	203.97	243.96	20.00	234.32	221.41	140.02	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
436.27	239.72	183.70	294.62	104.00	360.44	135.55	117.49	331.44	124.28	104.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
412.72	253.96	183.45	265.91	130.24	326.72	101.36	150.91	298.68	116.55	101.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
391.52	320.87	231.76	230.53	211.10	260.56	32.66	224.78	216.54	109.18	32.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
461.22	255.90	206.90	317.68	112.78	378.00	149.56	100.44	339.36	110.82	100.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
413.71	362.54	273.48	249.30	248.32	256.70	58.14	248.68	187.93	101.24	58.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

405.20	328.29	241.84	243.83	213.63	269.92	45.43	220.23	217.96	95.99	45.43	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
513.09	300.68	260.84	364.95	151.67	412.70	182.38	89.56	354.08	90.72	89.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
455.50	394.54	311.03	290.47	270.48	285.48	101.59	252.73	192.90	82.10	82.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
442.17	292.45	224.82	288.90	159.94	333.50	103.03	152.04	285.09	75.18	75.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
										SUM	7.00	4.00	18.00	17.00	17.00	9.00	13.00	7.00	5.00	3.00

5.0 CONCLUSIONS

5.1 Problems

The first and foremost problem encountered during the programming stage of the project was the lack of familiarity with Java. It was not known that Java used, by default, radians instead of degrees. This led to massive errors and mistakes which, had it not been for the hand calculations used to assure accuracy, would not have been found. Once the errors were pinpointed, they were easily corrected using $\cos(x*(180*\text{Math.PI}))$ or $\sin(x*(180*\text{Math.PI}))$, which converted radians back into degrees.

Although not exactly a problem, The ECP was able to accomplish a task that it was not intended to do. This was to tell each airport, in the event of airspace shutdown, how many planes would be en route to land at the particular airport (see also, Recommendations).

5.2 Recommendations and Conclusion on Further Studies:

Numerous ideas were cut from the project in effort to direct attention to one particular area.

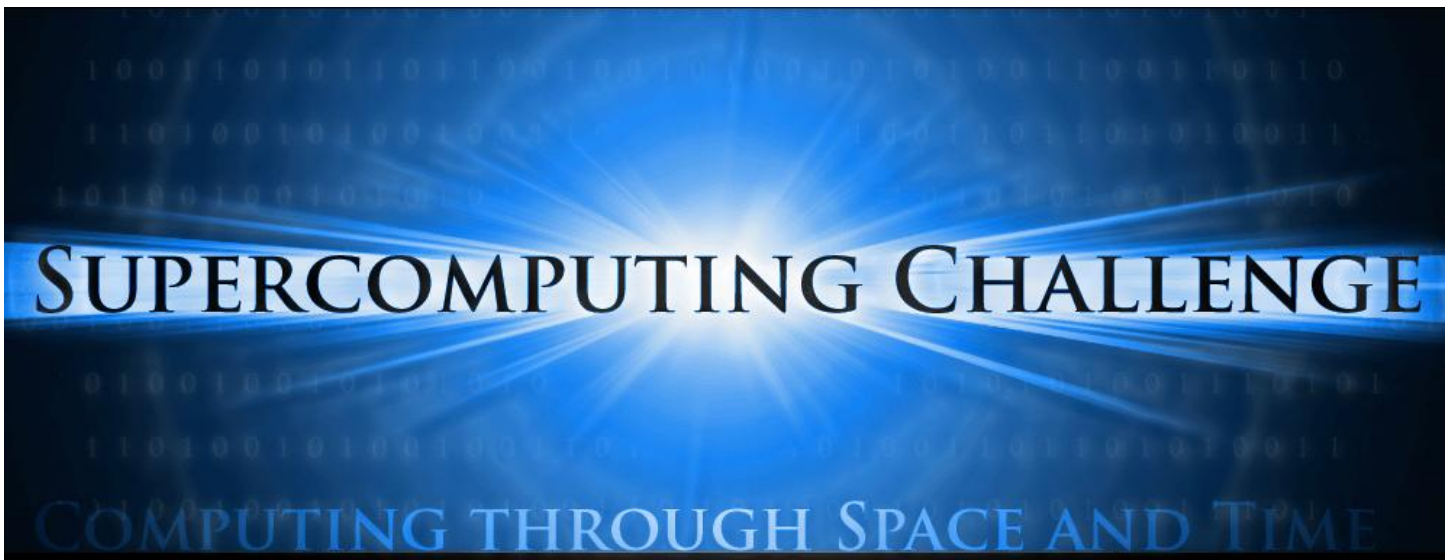
Among the ideas was one which was intended to nearly automate the work of airplane pilots as they waited for a spot on the runway. If a pilot reached an airport too early, the plane must “stack”, or circle above the airport to wait for a time to use the runway.

As previously explained, TAATCP’s reservation process caused planes to result with speeds was well below cruising speed. To combat this, we inserted the loop which defaulted speed below 480 MPH to 500 MPH. However, this caused planes to arrive before their prescribed time, which means that they must have “stacked”, or circled above the airport, until their turn to use the runway. It would have been an additional feature to this project to add a follow up program which coordinates those planes in stack. This program would assign the pilot a time in which the runway was reserved for the plane, and based on this time, calculate the altitude, speed, pitch, and angle at which he should fly at to reach final approach stage at the appropriate time. Of

course, this is where air traffic control and automated piloting begin to merge. Nonetheless, a project which sought to create an autopilot program as well as an autonomous air traffic control program would have become a task far too time consuming for our team to pursue.

Lastly, in retrospect, it would have been advantageous to combine ECP and CP into one program. Some may believe that they are actually strung together; they are not, although it would have been advantageous to have done so.

We believe that our most original and significant accomplishment in this project has been our development and exploration of new methods of automated air traffic control, whilst laying the foundation for further studies.



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