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Modelling reserving a proportion of ambulances for high priority calls

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A collaboration

PenCHORD
The Peninsula Collaboration for Health Operational Research & Development

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&
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Call handler
Triages calls

Dispatcher
Co-ordinates frontline responses

	Call handler	Dispatcher
Category 1 **Life threatening (8%)**	7 Minutes mean	**08:28**
Category 2 **Emergency (54%)**	18 Minutes mean	**27:31**
Category 3 **Urgent (26%)**	2 hours 90th percentile	**2hr 17 mins**
Category 4 **Less urgent** **(Categories 4 & 5: 12%)**	3 hours 90th percentile	**3hr 51 mins**

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What's the problem?

We need to get to our high acuity patients more quickly…

…whilst still getting to our lower acuity patients.

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What's the problem?

It is possible that all ambulances are occupied at the time a life-threatening emergency call comes in.

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What if…..?

Despatchers *reserve* a portion of resources for the higher acuity calls

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Questions…..Answers

- **What is the optimum level of resources to hold back in order to meet the needs of our category 1 patients?**
- **What impact will this have on the lower acuity patients?**
- **What is the optimum balance between these two?**

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Python

File Edit Search Source Run Debug Consoles Projects Tools View Help

Editor - C:\Users\fiona.willmott.NHSD\Documents\HSMA\ambo\181113_fiona.py

181113_fiona.py | scneario_testing_fw.py | PlotBaseLine_FW.py | plot_2.py | Scenario_Testing_loop

```
import simpy
import random
import queue
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd


class g():
    """global variables"""
    audit_time_res = []
    audit_res = []
    audit_q = []
    audit_q_count = 0
    audit_time_q = []
    audit_interval = 10
    demand_by_priority = np.zeros(5)
    demand_met_by_priority = np.zeros(5)
    inter_arrival_time = 5
    loj = 90
    patient_counter = 0
    queueing = 0
    sim_duration = 288000
    q = queue.PriorityQueue()
    q_times = []
    q_priority = []
    queue_numbers_by_priority = [0, 0, 0, 0, 0]
    resource_in_use = 0
    resource_time_by_priority = np.zeros(5)
    reserved_resource =  0
    total_resource = 20
    warm_up_time = 1440


def allocate_res(env, p_loj):
    """When resource is known to be avialble, number of resources in use is
    incremented,a SimPy timeout is called (for the duration of the job, then
    resources in use is reduced, and the queue is again reviewed"""
    g.resource_in_use +=1
    yield env.timeout(p_loj)
    g.resource_in_use -=1
    review_queue(env)


def audit_q(env, delay):
    """audit queue. Called at regular intervals"""
    yield env.timeout(delay)
    while True:
        g.audit_q_count +=1
        g.audit_time_q.append(env.now)
        g.audit_q.append(g.queueing)
        if g.audit_q_count == 1:
            g.audit_q_priority = np.array(g.queue_numbers_by_priority)
        else:
            g.audit_q_priority = np.vstack(
                    (g.audit_q_priority,np.array(g.queue_numbers_by_priority)))
        yield env.timeout(g.audit_interval)
```

C:\Users\fiona.willmott.NHSD\Documents\HSMA\ambo

Help | Source Console | Object

Usage

Variable explorer | File explorer | Help

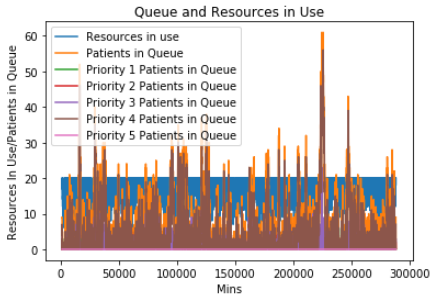
IPython console

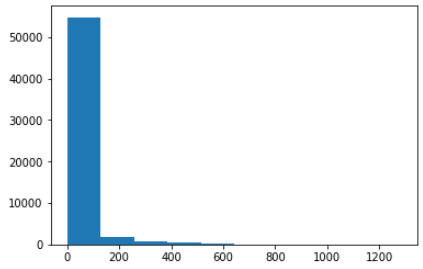
Console 1/A

```
Python 3.6.4 |Anaconda, Inc.| (default, Jan 16 2018, 10:22:32) [MSC v.1900 64
Type "copyright", "credits" or "license" for more information.

IPython 6.2.1 -- An enhanced Interactive Python.

In [1]: runfile('C:/Users/fiona.willmott.NHSD/Documents/HSMA/ambo/181113_fiona
```






```
C:/Users/fiona.willmott.NHSD/Documents/HSMA/ambo/181113_fiona.py:227: RuntimeW
  demand_met = (g.demand_met_by_priority/g.demand_by_priority) * 100
   reserved_resource  priority  demand_met_percent  \
0                0.0         1          100.000000
1                0.0         2          100.000000
```

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A simplified model - assumptions

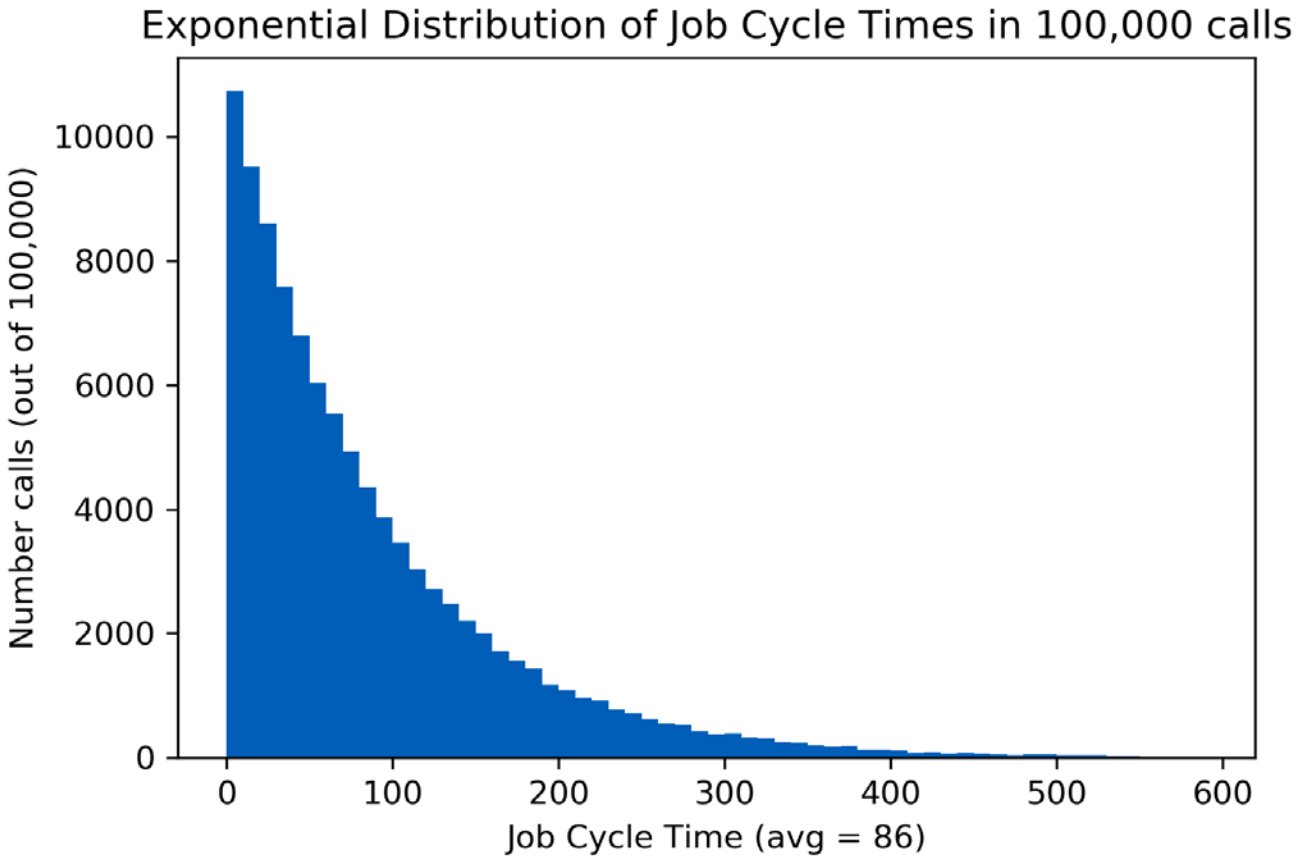
A system with 20 available ambulances.
This is similar to the resources available in the despatch area of South and West Devon.

Geography ignored
We have assumed that any available ambulance can be allocated to any call.

Allocation time not response time
This will still give us an accurate idea of the changes to the waiting times.

Category	**%**	**Mean Job Cycle Time (Length of time from resource allocated until clear again)**	
Category 1	7	86 mins	Assumed negative exponential distribution
Category 2	58	93 mins	
Category 3	25	100 mins	
Category 4	10	100 mins	

A simplified model - assumptions



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A simplified model - assumptions

Inter Arrival Time
This is the amount of time that elapses between each call coming in. The incoming call rate.

The 6 month simulation was run 20 times, with different mean inter arrival times each time, to demonstrate how the system works under different levels of stress.

The inter-arrival time for each call is also sampled from the negative exponential distribution

Peaks and Troughs Ignored
Peak hours and weekend peaks are not currently included

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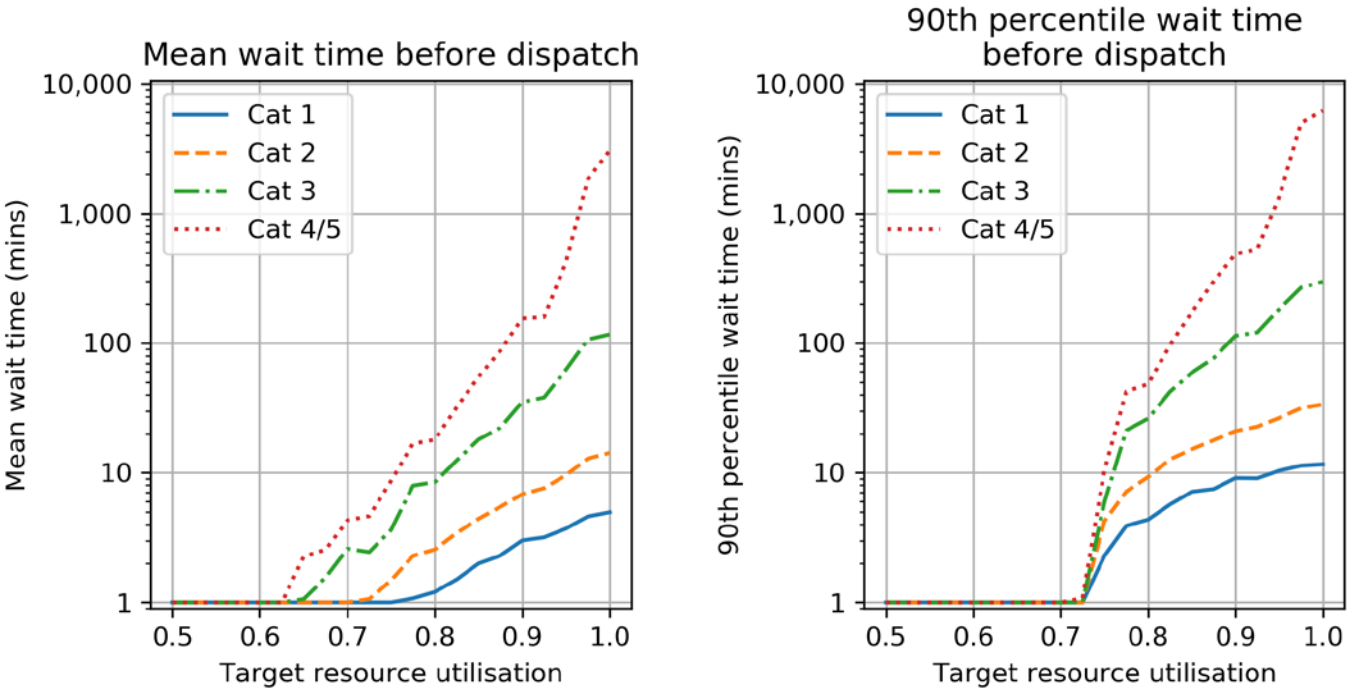
Baseline

Total Resources = 20 Reserved Resources = 0



85% utilisation	mean (mins)	90th %ile (mins)
Priority 1	2	7
Priority 2	4	15
Priority 3	18	59
Priority 4	54	172

93% utilisation	mean (mins)	90th %ile (mins)
Priority 1	3	9
Priority 2	8	22
Priority 3	38	120
Priority 4	158	531

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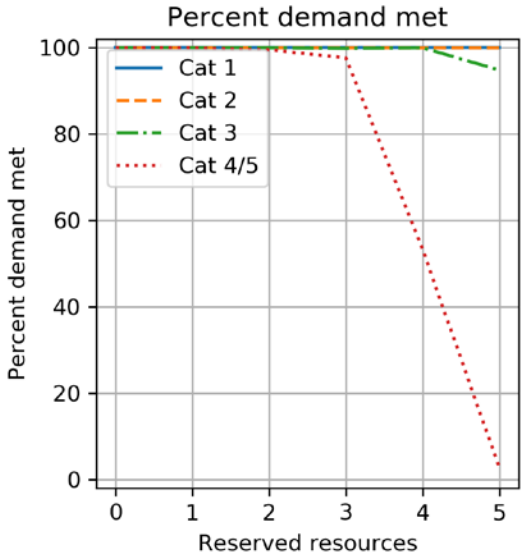
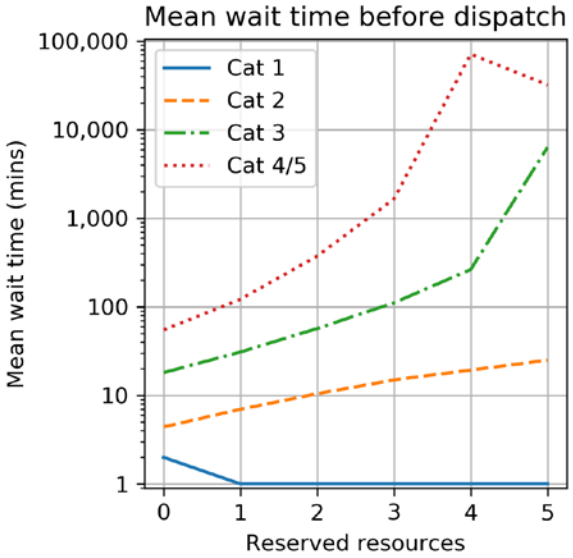
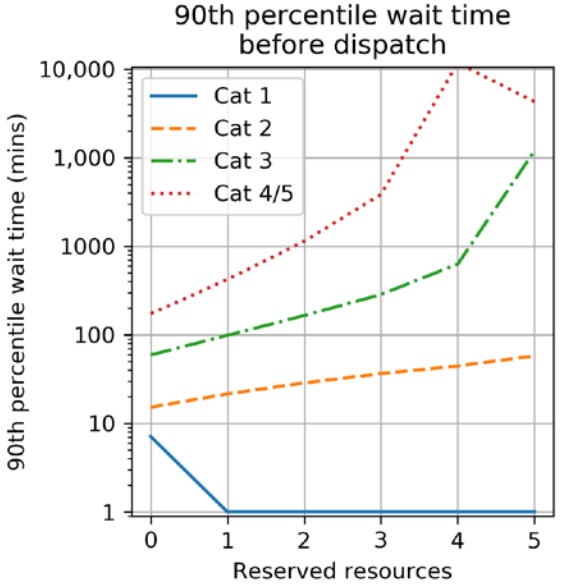
Reserving Resources at 85% utilisation

Target resource utilisation = 85 percent (20 ambulances total)







0 reserved	mean (mins)	90th %ile (mins)
Category 1	2	7
Category 2	4	15
Category 3	18	59
Category 4	54	172

1 reserved	mean (mins)	90th %ile (mins)
Category 1	0	0
Category 2	7	21
Category 3	30	98
Category 4	122	420

2 reserved	mean (mins)	90th %ile (mins)
Category 1	0	0
Category 2	10	29
Category 3	56	165
Category 4	373	1136

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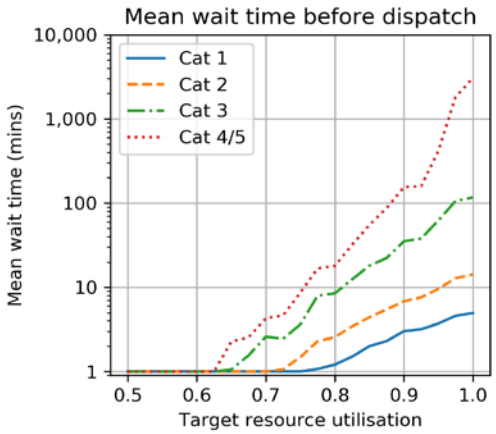
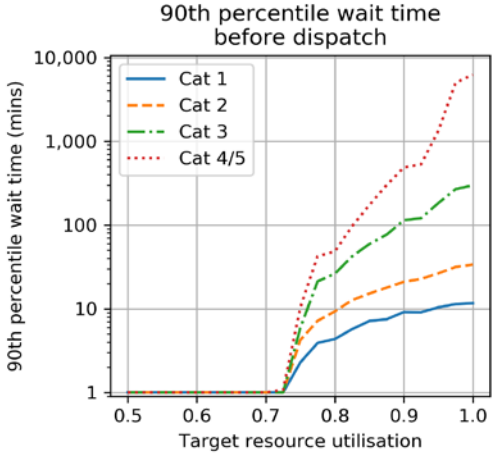
Reserving 1 or 2 Resources

Baseline

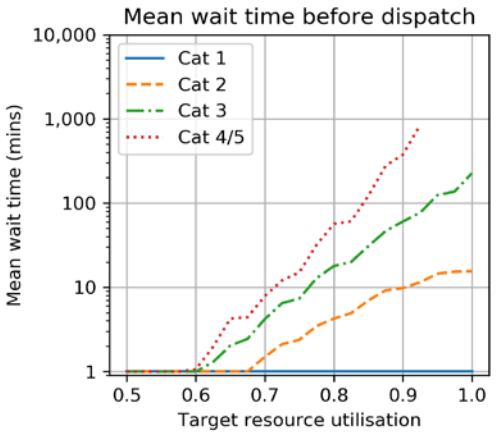
Total Resources = 20 Reserved Resources = 0

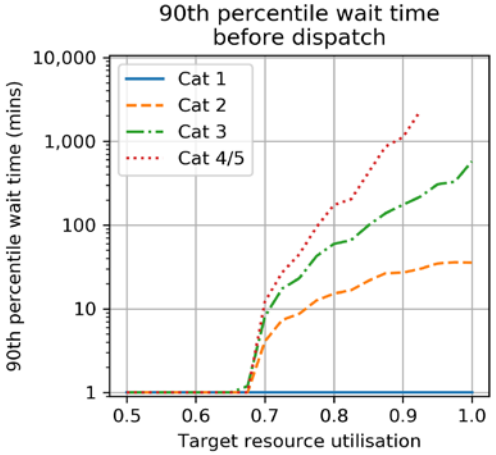




Reserve 1 resource

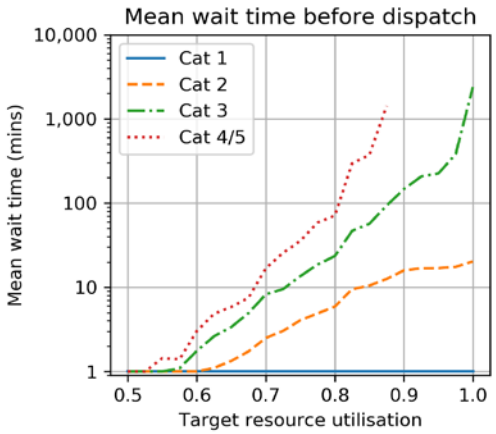
Total Resources = 20 Reserved Resources = 1

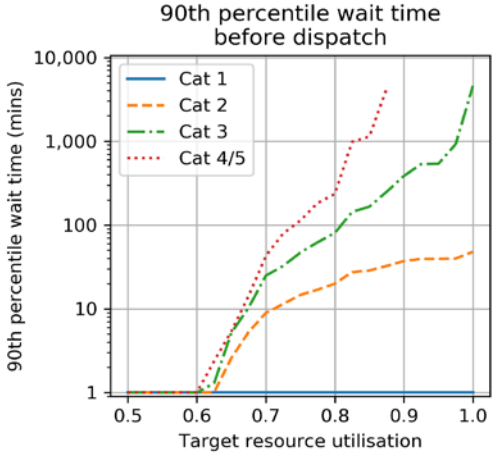




Reserve 2 resources

Total Resources = 20 Reserved Resources = 2





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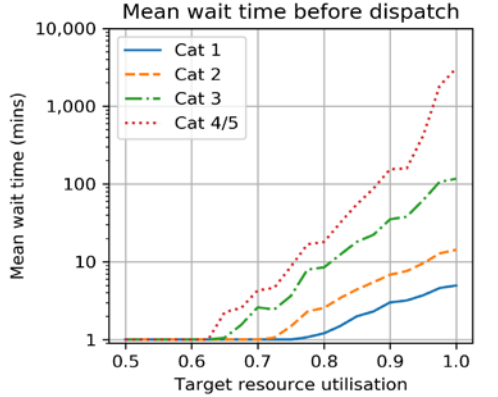
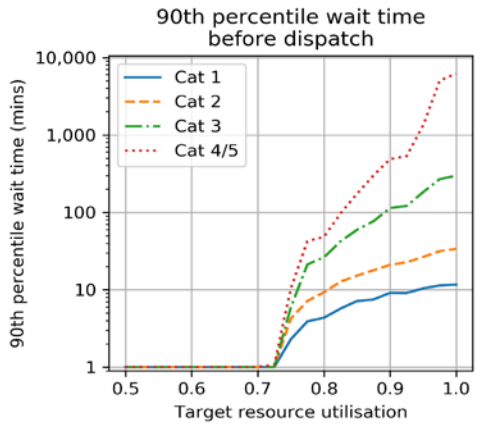
Reserve for Category 2 as well

Baseline

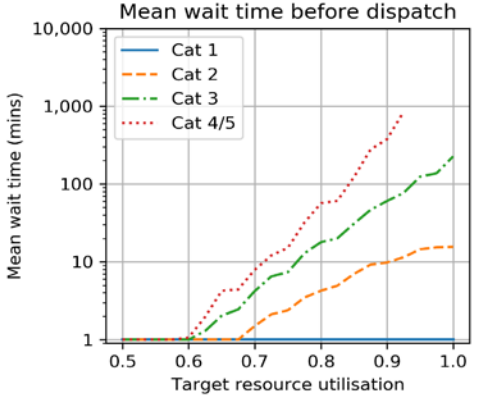
Total Resources = 20 Reserved Resources = 0

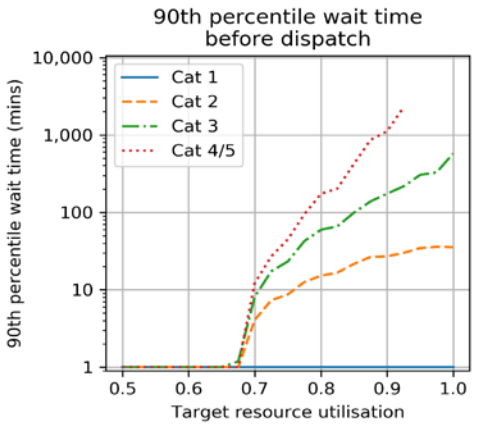




Reserve for Cat 1

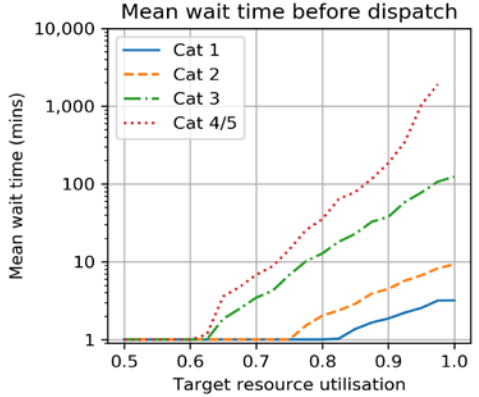
Total Resources = 20 Reserved Resources = 1

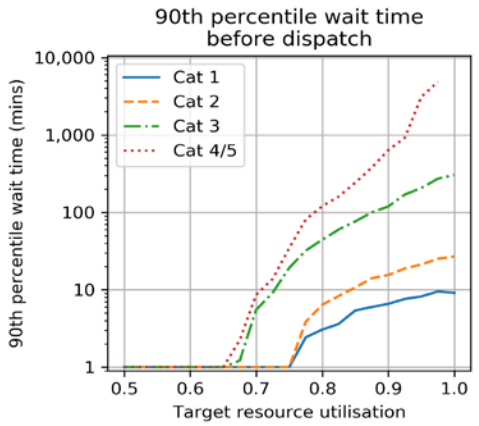




Reserve for Cat 1 & Cat 2

Total Resources = 20 Reserved Resources = 1





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Call handler
Triages calls

Dispatcher
Co-ordinates frontline responses

	Call handler	Dispatcher
Category 1 **Life threatening (8%)**	7 Minutes mean	07:00
Category 2 **Emergency (54%)**	18 Minutes mean	27:08
Category 3 **Urgent (26%)**	2 hours 90th percentile	2hr 43 mins
Category 4 **Less urgent** **(Categories 4 & 5: 12%)**	3 hours 90th percentile	3hr 39mins

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Next steps

Refine the model

HSMA has raised the awareness/skills of modelling within the trust

Start modelling earlier

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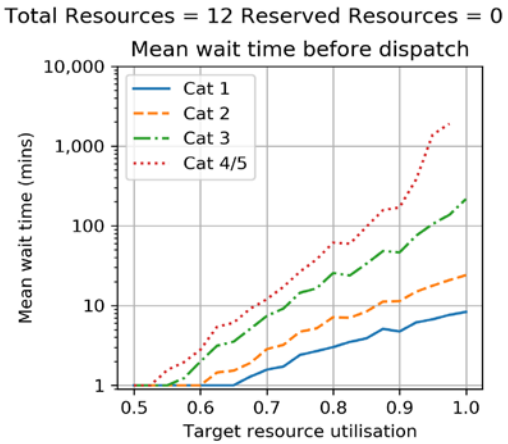
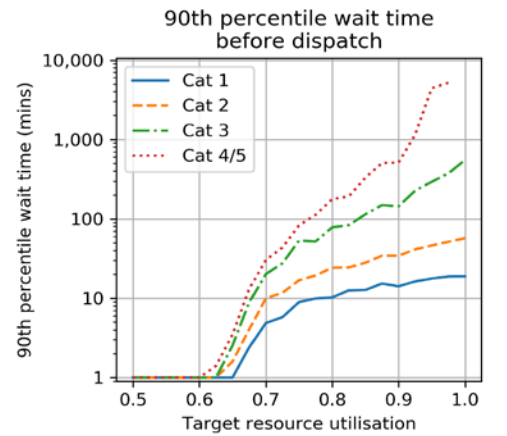
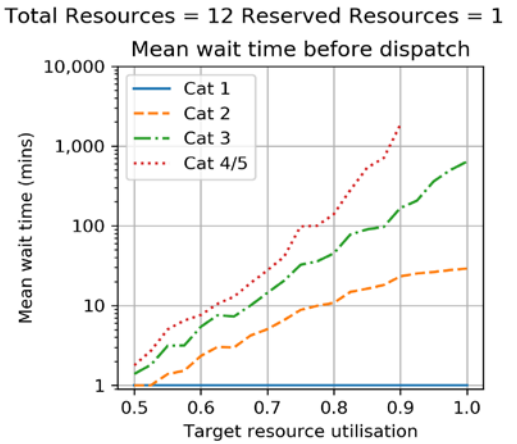
Smaller area – 12 ambulances

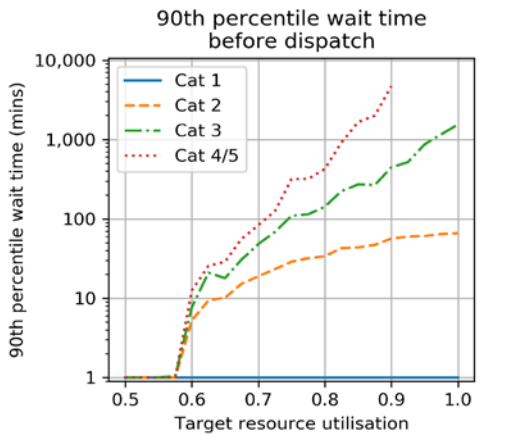
Baseline



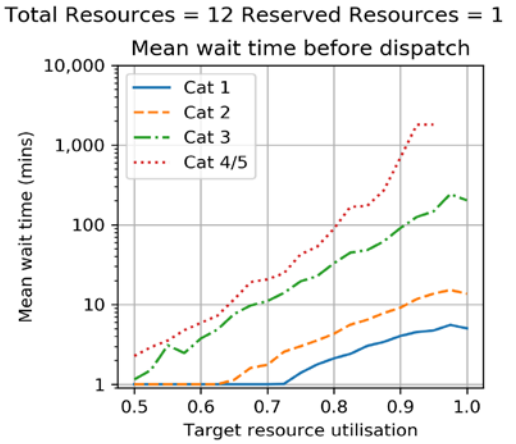


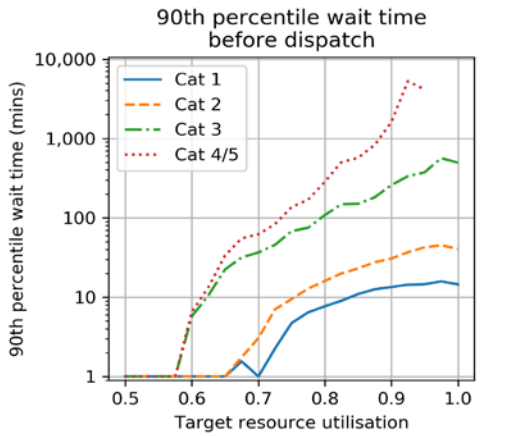
Reserve for Cat 1





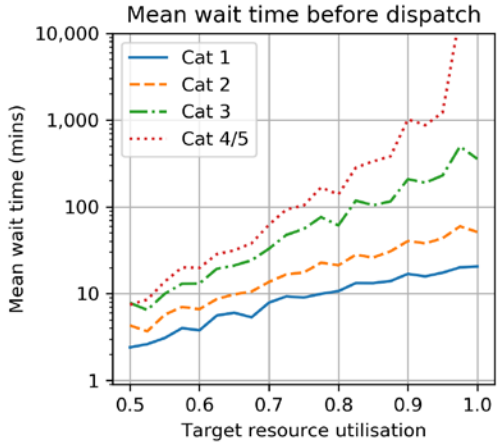
Reserve for Cat 1 & Cat 2





Smaller geographical areas: 5 ambulances

Total Resources = 5 Reserved Resources = 0



Total Resources = 5 Reserved Resources = 1