Using FRAM for Hospital Bed Allocations

Presentation to FRAMily 2023

Copenhagen

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Acknowledgements

Ralph MacKinnon – who should have been giving this presentation

Jacob Barnaby – Did the initial process observations

Rees Hill – made the Metadata work

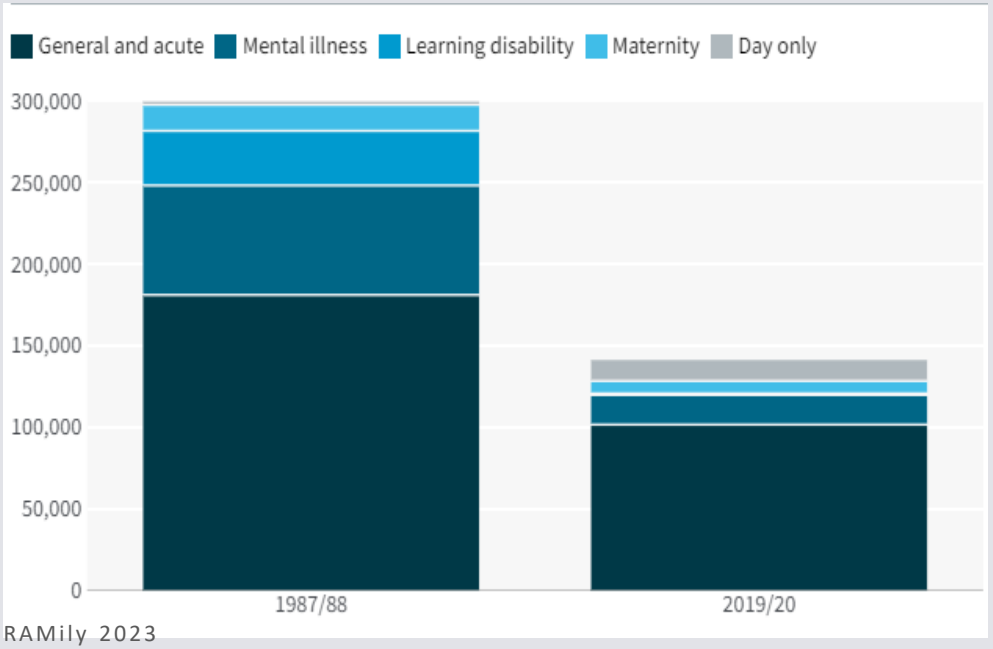
Nomoto Hideki – who developed and supervised the machine learning capability and proof of concept

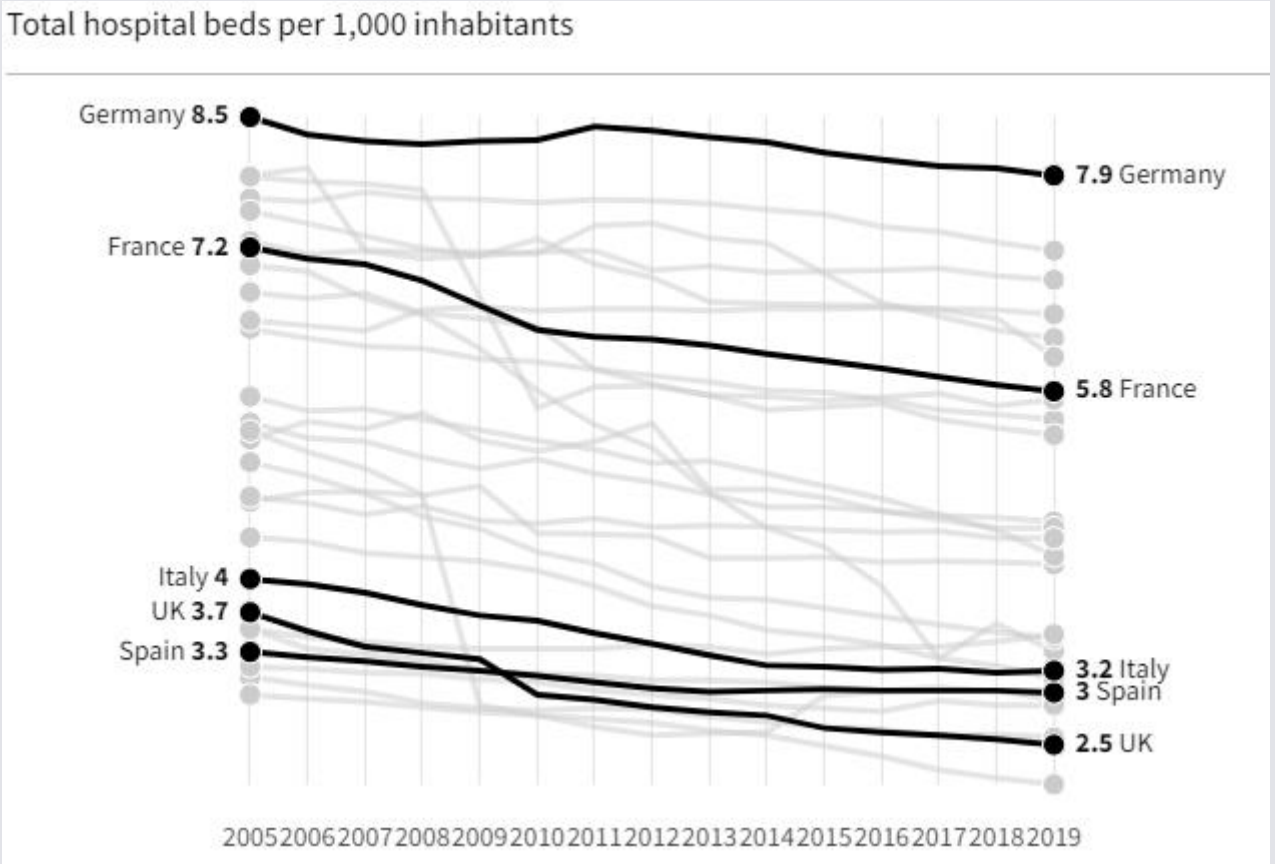
And Manchester Hospitals Foundation Trust who are encouraging and successfully applying the FRAM approach in patient healthcare safety.

Bed numbers have halved

Demand has escalated – Covid, Ageing Population

UK Hospital Bed Availability





Optimal Allocation of a scarce resource – a real problem!

Managed by a complex sociotechnical system

Under continual stress – life and death!

The Problem

Supply and demand!

Already at (more than?) maximum utilisation

Uncertainty in availability – both numbers and timing

Unpredictability of emergencies – internal and external

No apparent protocols or processes

Priority cases override planned procedures

Major incidents throw out the book!

Competing Processes and priorities

There is a daily wish list of X cases (children) scheduled for elective surgery (C3PO)

This requires X critical care beds to be guaranteed before the daily surgical list can be started – but they are last in line –

– life critical cases naturally have priority

These are patients already in the wards who now need urgent surgery (escalation EI)

There are Emergency cases transferred in from the Emergency Department (ED)

There are other emergency patients referred from other hospitals.(ER)

And finally major emergencies (Road Traffic Accidents)

Work as Imagined?

All the right people meet in the morning (8:30) and allocate the available beds.

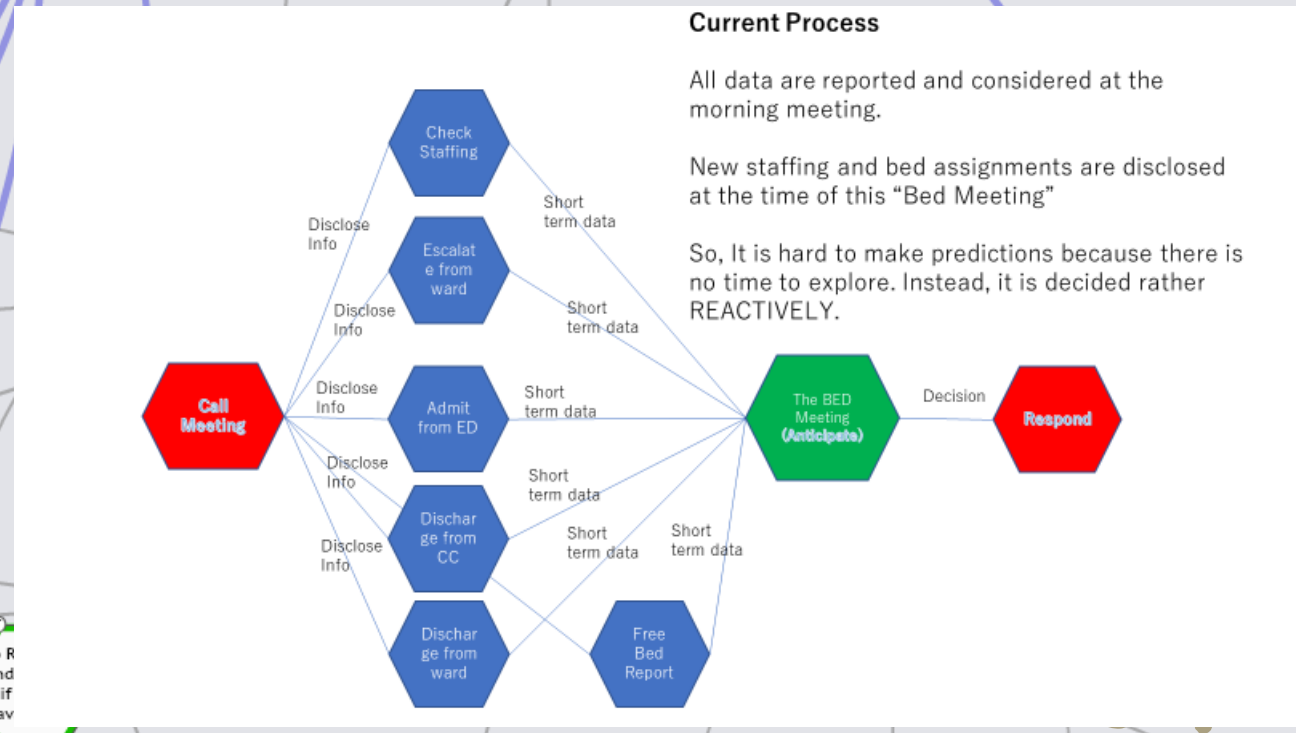
If insufficient beds are available, the C3PO list is reduced and children, (already prepped?) are reassessed and go back on the waiting list.

If an unplanned emergency happens, during the day and needs extra beds – these can be “improvised”

Are there ever any unexpected unfilled beds left over at the end of the day?

How can we (FRAM) help?

We can model the current process



Work as Done

Speculation ------!

The bed allocations decided at 9am are out of date by 10am?

Last minute complications in discharging patients from critical care, sudden deterioration of existing patients and unforeseen admissions demand constant readjustment of thinking and priorities?

So, “experienced” ward sisters and consultants are continually re-addressing, re-evaluating, availabilities and “probable” demands and outcomes, ETTO –ing naturally to adapt to developing situations.

But this is necessarily reactive, any attempts to rely on predictions are “dangerous”?

But experienced staff have to do it, anyway (unconsciously?) to assess the real “risks” not the qualified certainties of the 9am decisions.

But FRAM can also keep track of the changing data

We can use the Metadata facility to MONITOR the bed numbers need and available to the “decision meeting” function. “

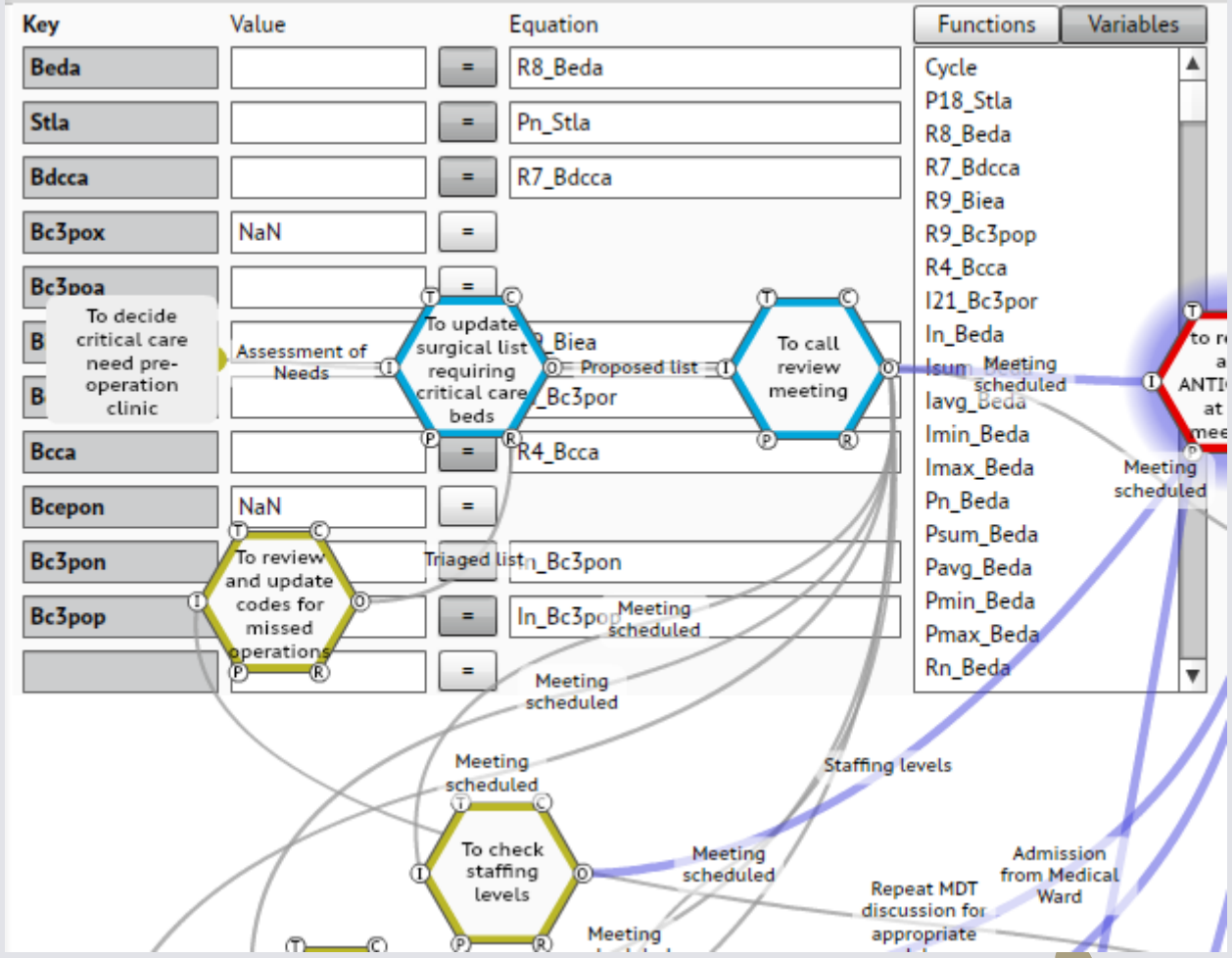
“Key” is Bed source identifier,

“Value” is the number of beds

The patient data underpinning these bed numbers is recorded in the HIVE data base, and available across all hospitals

(HIVE stands for Hospital Information and Virtual Environment).

Interface with the HIVE database, the Electronic Patient Record (EPR) solution used by Manchester University NHS Foundation Trust (MFT) hospitals.



Learn Daily Patterns

We know the Total numbers of beds available that day and (average?) individual needs ED, EI and ER

We know the average number of CC patients discharged per day.

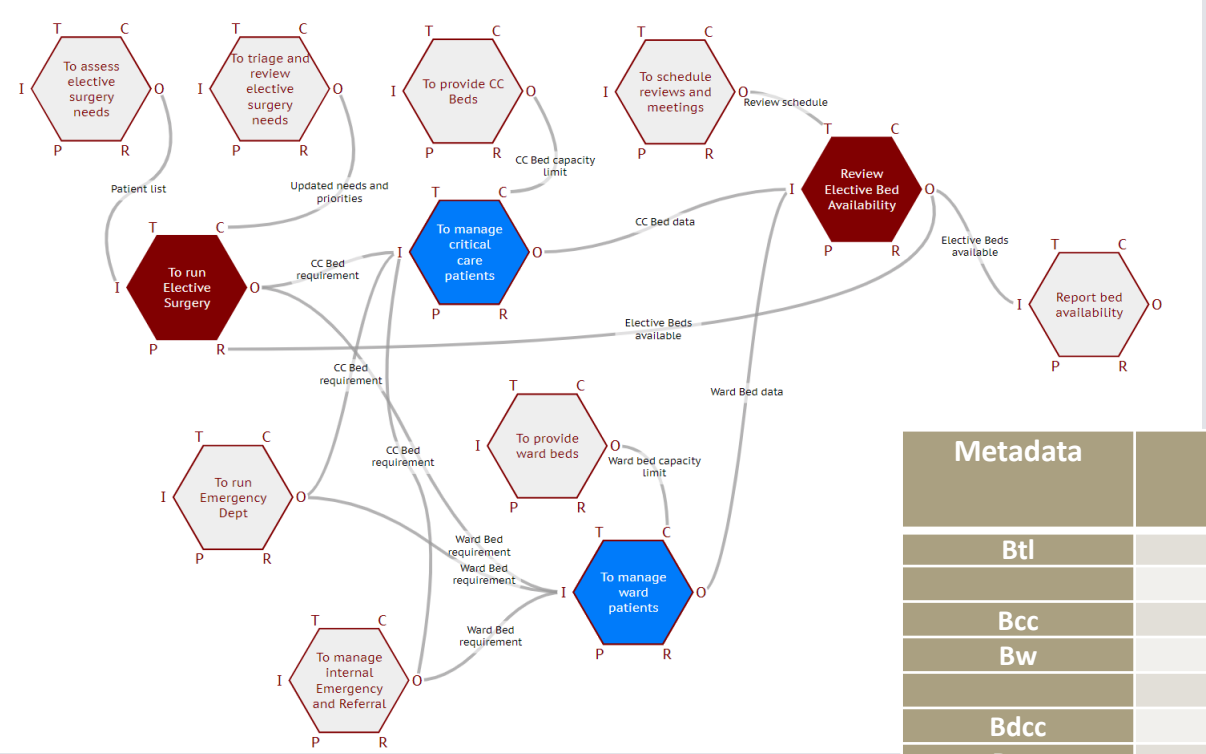
And we know from the record the average length of stay in CC beds

So, we can estimate the number of beds likely to be freed up

Use Distributions rather than averages, for 90 / 95% probability of availability of C3PO beds?

Parameter	Hospital Beds	Critical Care Beds	Ward Beds	Bid %	Average Available	%
Total	150	40	110			
Assigned to Elective	25	2	23			
Assigned to ED	25	2	23			
Assigned to EI / ER	100	1	99			
CC beds discharged		26			26	65
If stay is 1 day		40				
If stay is 3 days		13.33333333				
Ave length of stay		1.538461538				
Discharge % B/d		65				
C3PO bid		3	23	11.53846	1	3.846154
ED beds needed		13	24	50	13	100
Ave ED beds needed		13				
EI/ER needed		12	60	46.15385	12	100
Ave EI/ER beds needed		12				

Test it out?

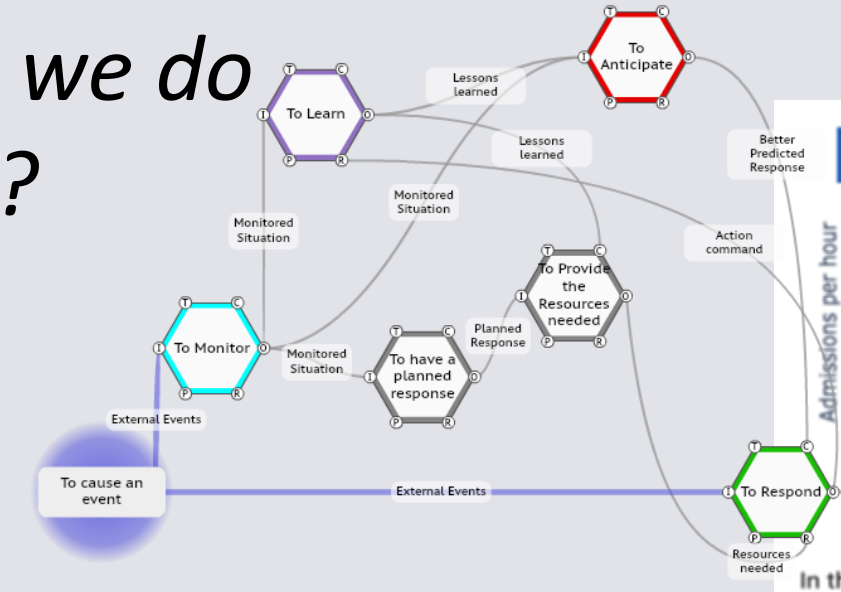


Metadata - test case

KEY	Values						
	Elective Surgery	Emergency Dept	Internal Emergency or Referral	TOTAL	Discharge Beds/day	Ave length of stay	Discharge % Beds/day
CC Bed Limit	2	2	36	40			
Ward Bed Limit	23	23	64	110			
Total Bed Limit	25	25	100	150			
CC Bed Want	3	13	12	28			
Ward Bed Want	23	24	60	107			
Total Bed Want	26	37	72	135			
CC Bed Available	?	?	?	26	26	1.538462	65%
Ward Bed Available							
Total Bed Available							
CC Bed Allocation	1	13	12	26			
Ward Bed Allocation							
Total Bed Allocation							
	C3PO	Constant / Actual	Calculated / Predicted				

Metadata	Test Run Key	Description
Btl	Bed-total	Hospital Beds in Total
Bcc	Bed_limit_CC	Total No. of Critical Care beds
Bw	Bed_limit_Ward	Total No. of Ward beds
Bdcc	Bed_ available_CC	No. of CC beds made available by discharging patients
Bwa	Bed_available_Ward	No. of Ward beds available
Bc3po	Bed_required_CC	No. of CC beds sought for elective surgery
Brw	Bed_required_Ward	No. of Ward beds required
Bc3poa	Bed_elective_CC	No. of CC beds assigned to elective surgery

But could we do more still?

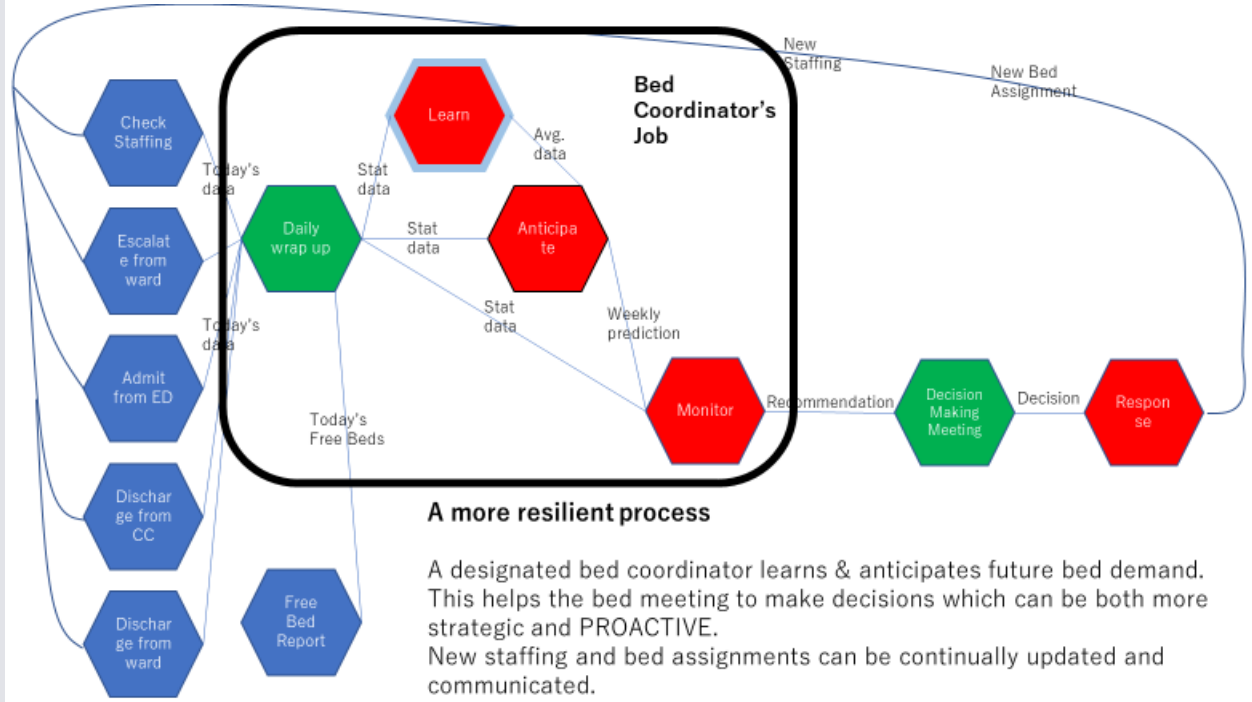


Add RESILIENCE –

The Functions to LEARN, ANTICIPATE and RESPOND

Interface with the HIVE database, the Electronic Patient Record (EPR) solution used by Manchester University NHS Foundation Trust (MFT) hospitals.

A previous study by the Skunkworks showed that Hourly predictions for up to a week ahead are possible as above.



Use ANN to learn system behaviour and predict "Availability Values"

- Bayesian Predictor - *Nomoto Hideki et al*

Objective:

To build Bayesian Network using FRAM

Output value:

Currency Exchange Rate prediction

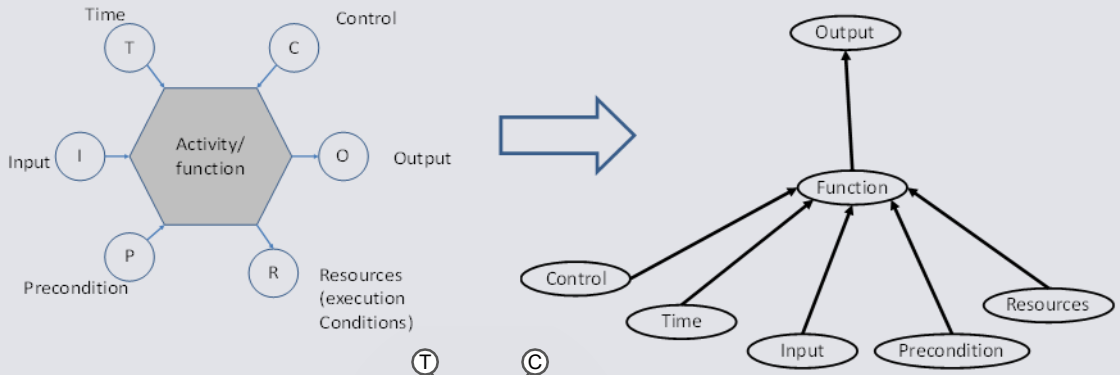
Input values :

Short term interest rate

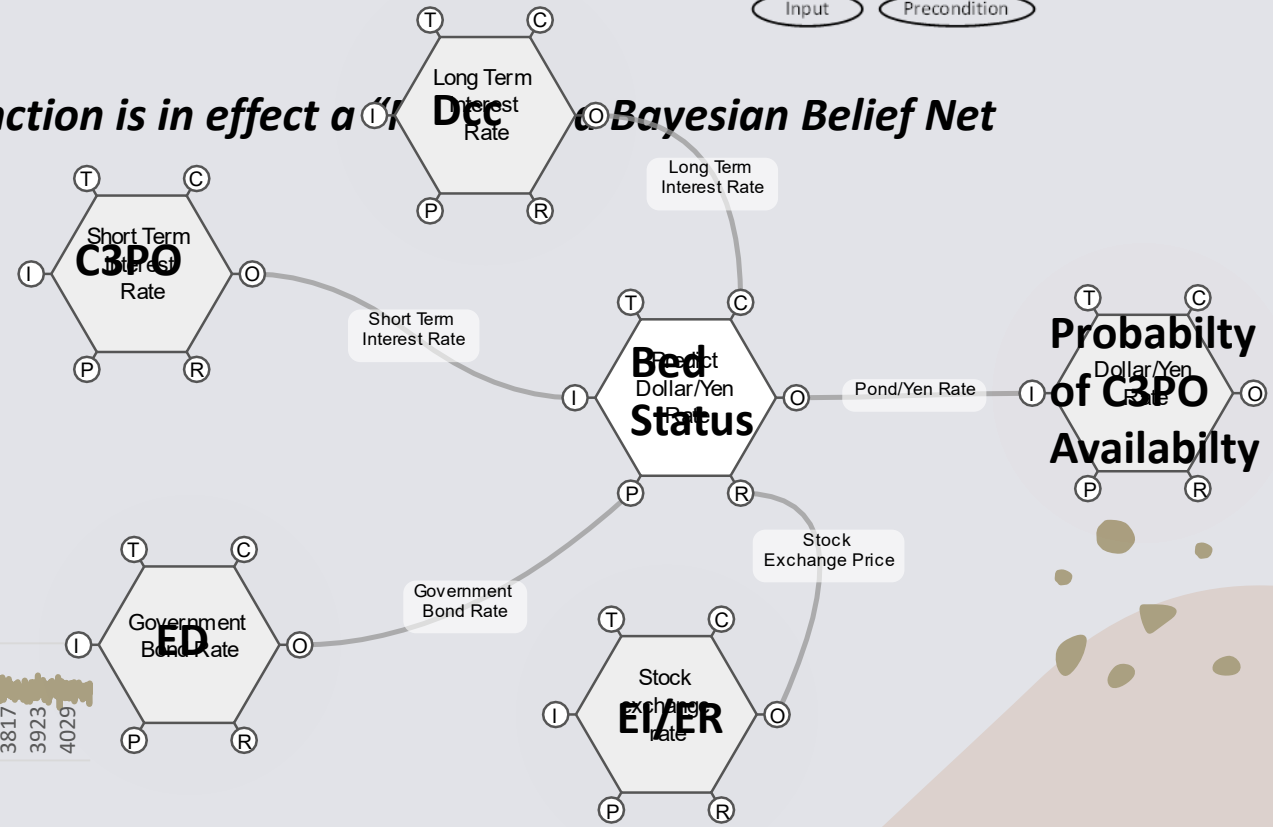
Long term interest rate

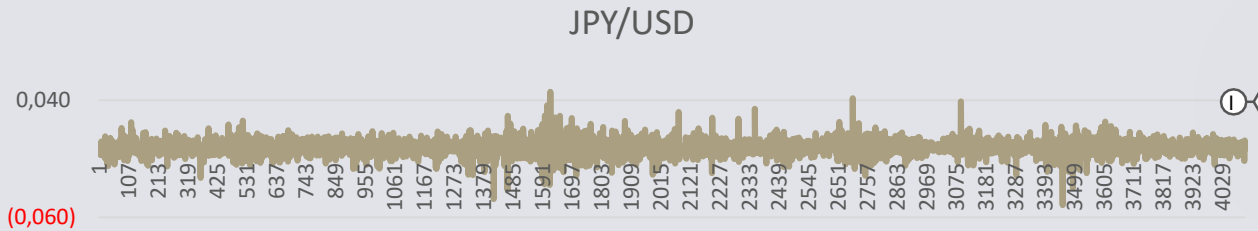
Stock exchange rate

Government bond price

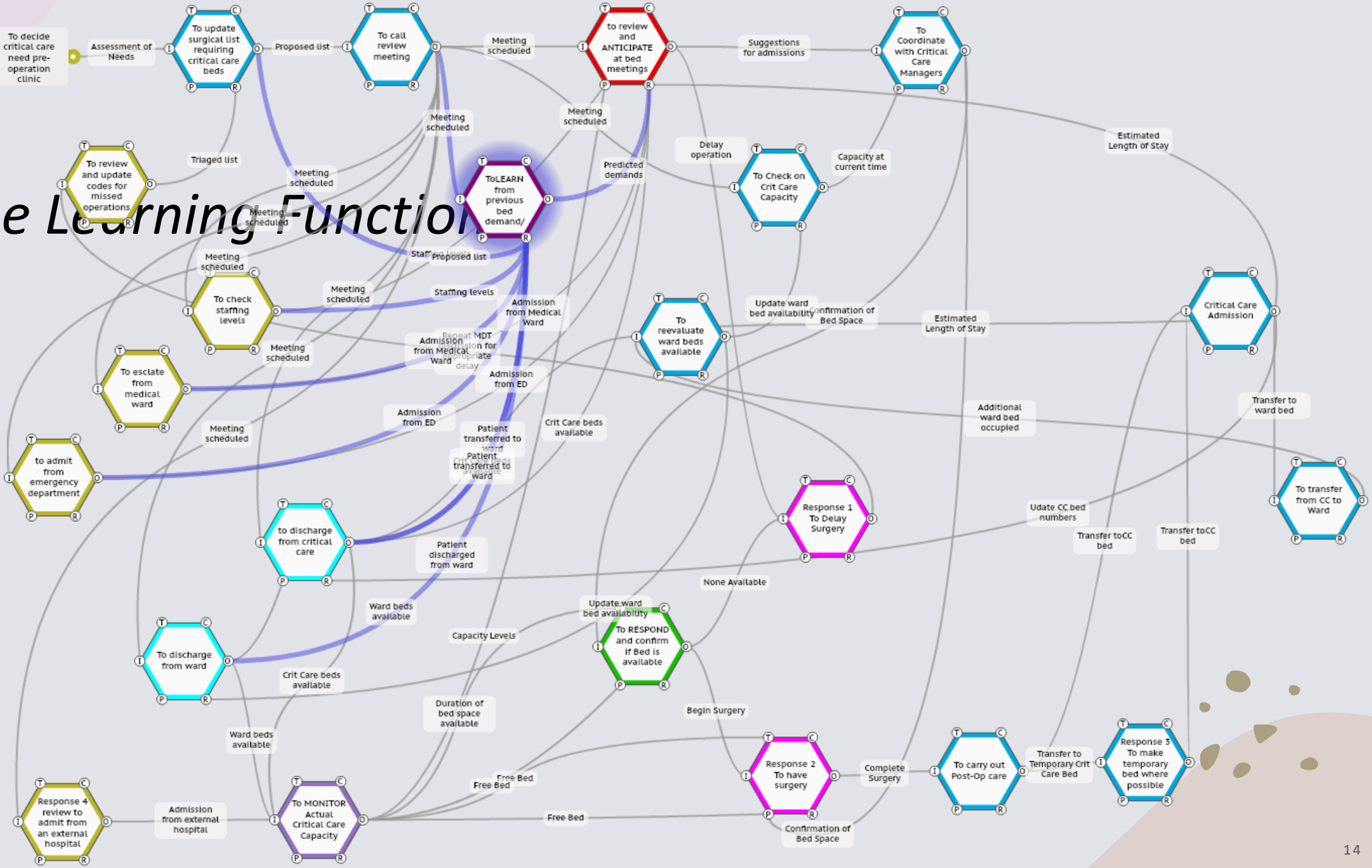


A FRAM function is in effect a "Node" of a Bayesian Belief Net





Add the Learning Function



Next steps

As an initial attempt, this needs to be further developed by:-

- Improving the FRAM with feedback and editing from the people involved (actual Work as Done”!)
- Exploring extra degrees of freedom possible if the demand side can be predicted more accurately / sensitively?
- For example, could we utilise the HIVE data to indicate probability of escalation and discharge numbers more accurately?
- Also are there inferences / signals from the emergency department (ED), (e.g., average waiting times?) that could better predict ED demand?

What it is not!

- The objective is to assist in allocating a bed to a patient
- It is intended to be used in a Human-in-the-loop (HITL) approach (meaning the tool is an information source for a human, who makes decisions using the tool as well as other sources).
- The approach does not attempt to capture the complex, nuanced understanding that a bed manager possesses, which only they can provide.
- But it does provide a transparent way to view as to how and why a bed allocation suggestion has been made

Thankyou!