# Dynamic business models for Systems Engineering (SE)

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sdcourses.com

Get the slides sdl.re/sds08slides

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## For business leaders

How systems engineering (SE) contributes to ***enterprise*** issues, especially with dynamic models



## For SE professionals

How system dynamics models* offer "model-based systems engineering" for tackling enterprise issues

* The system dynamics community includes many systems engineering professionals.

Systems Engineering for enterprise-level issues

Demo – a simple project challenge

What dynamic models add to systems engineering efforts

Next steps

# Systems Engineering

" … for the understanding, creation, use, and sustainment of engineered systems to enable the realization of stakeholder needs"

*Historically: a vast range of engineered physical systems – products, projects, supply-chain, manufacturing etc.*

+

***Increasingly***: Enterprise-***management*** issues*

* The SE body-of-knowledge 'SEBoK'.

# Towards Model-Based Systems Engineering (MBSE)

***HISTORIC: Document-based Systems Engineering***

... developing, testing, deploying systems by creating and controlling documentation

***Increasingly: Model-based Systems Engineering ****

... developing, testing, deploying systems with models that capture the system's behavior, functions, and physical characteristics

***Already well-established***

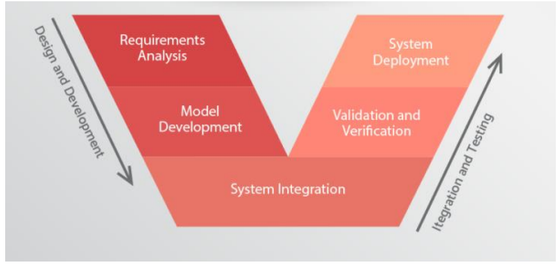
*Models for a vast range of engineered physical systems*

+

***Models*** for Enterprise-level management issues

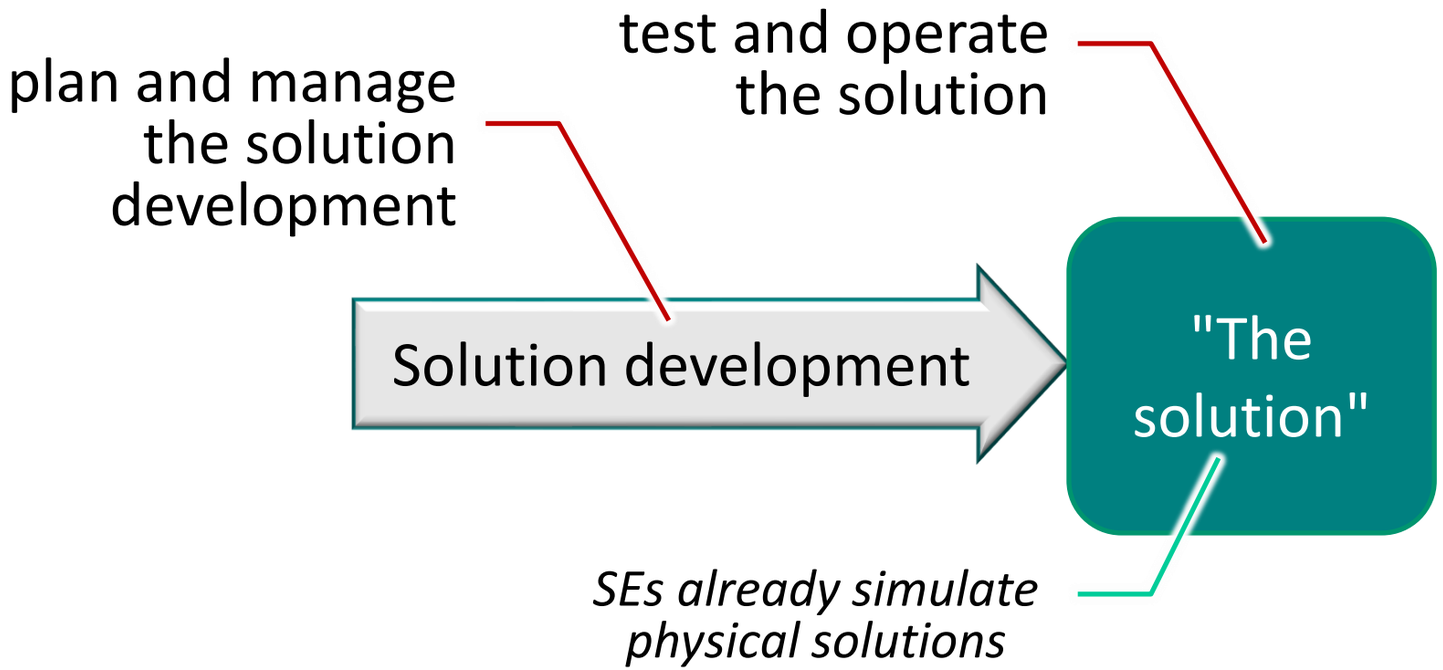
*Great potential for …*

The MBSE process




* See the INCOSE/IEEE 'MBSE initiative'.

# Possible simulation contributions to MBSE for Enterprise issues …




“The solution” may concern any strategy, challenge or initiative, small or large – for the entire enterprise or any part

# Three related dynamic modeling methods

What do analysts, consultants and accountants currently use for enterprise modeling? *Spreadsheets* … not fit-for-purpose !!

***Discrete-event simulation*** (DES) – how items move through a system

***Agent-based modeling*** (ABM) – how autonomous entities interact

*… both are powerful tools for entity-detail, time-detail modeling*

***System dynamics*** – continuous simulation of interacting populations

**… compact, quick to build, handles all system elements** (*cash, people, physical items, intangibles* …)

"*Discrete event simulation, system dynamics and agent-based simulation: Discussion and comparison*", R Maidstone, System 1(6), 2012.

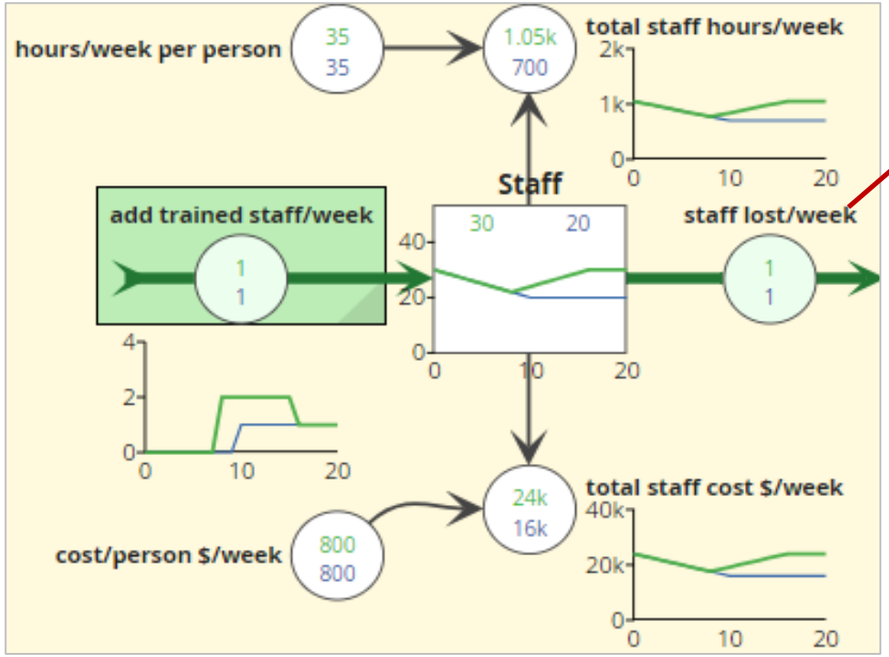
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# SD model example: *staff,* work-capacity and cost over 20 weeks




green/blue : alternative hiring scenarios

Think of each item as a *spreadsheet column*

… with its *name* in the top cell

and each period's *values* in the cells below

The *arrows* are like cell references (*but you can't make cell-ref errors*!)

Each item holds a simple-language formula …

```
total staff hours/week
    = Staff * hours/week per person
```

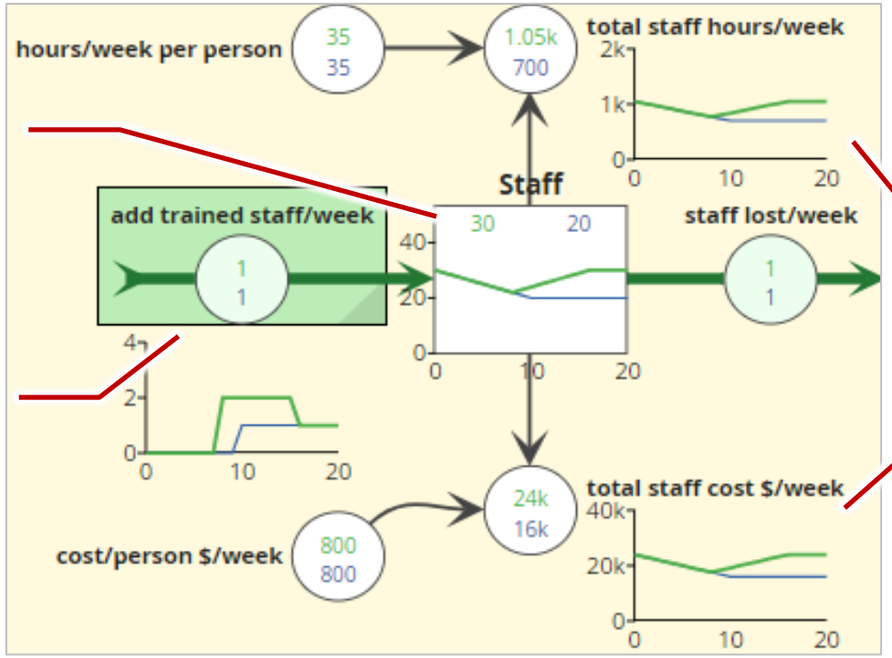
… not C17 = A17 * $B$2!

Try it yourself at sdl.re/SEstaff

# The universal principles of SD models

2: Performance at each point in time *depends on "stocks"* – factors that accumulate and deplete (*see* [sdl.re/LIPstocks](sdl.re/LIPstocks))

3: *"Flow-rates"* change the value of every stock from period to period




1: The aim is to understand and improve *performance over time*

4: (*we will see later)* the value of every flow-rate at each point in time *depends on current stock-values*

These principles provide a rigorous, 'agile' 4-step process for building reliable quant, simulations (see sdl.re/LIPagileSD)

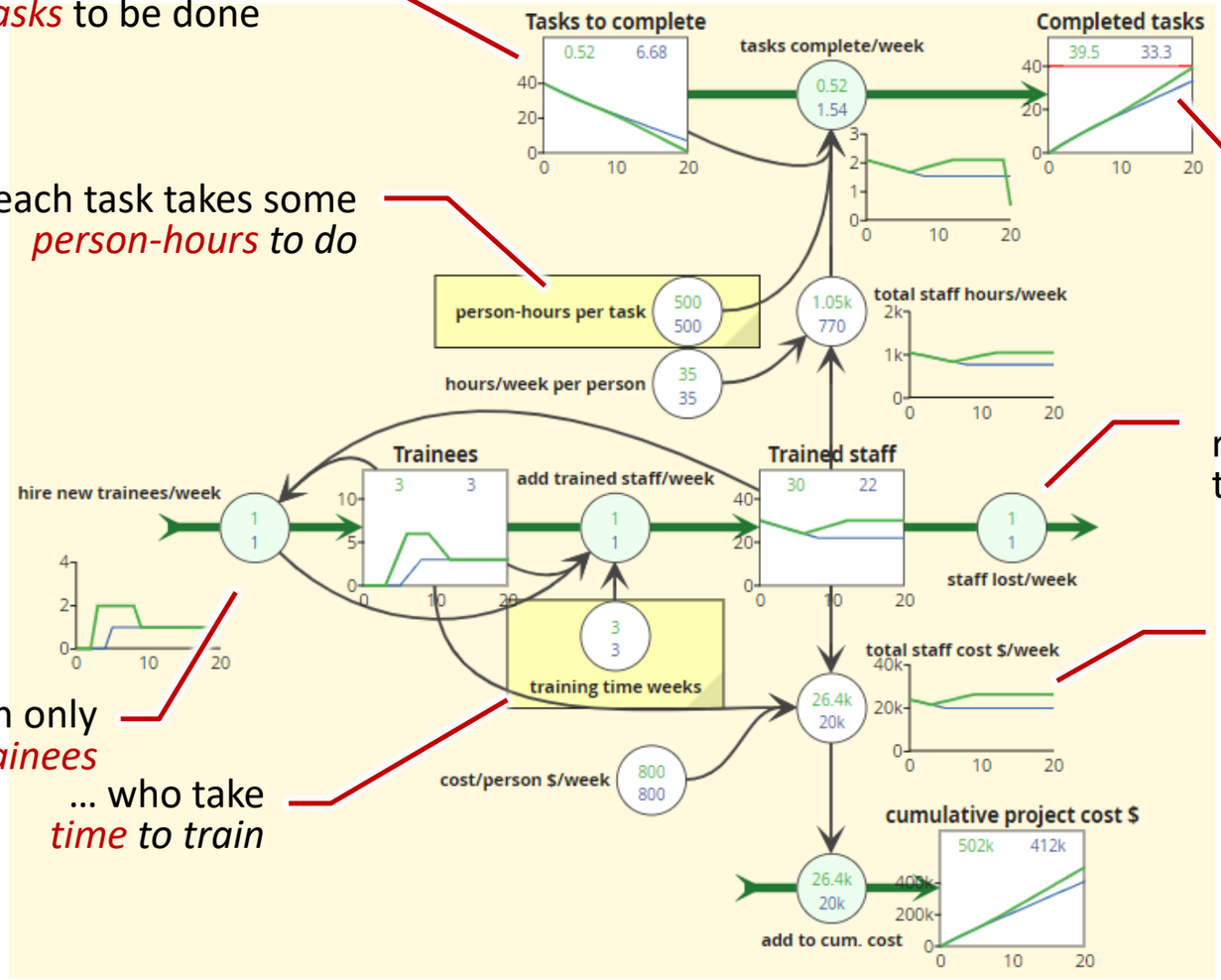
# Let's get those staff to complete a *project*

the project starts with a Stock of *tasks* to be done

each task takes some *person-hours to do*

we can only hire *trainees*

… who take *time to train*



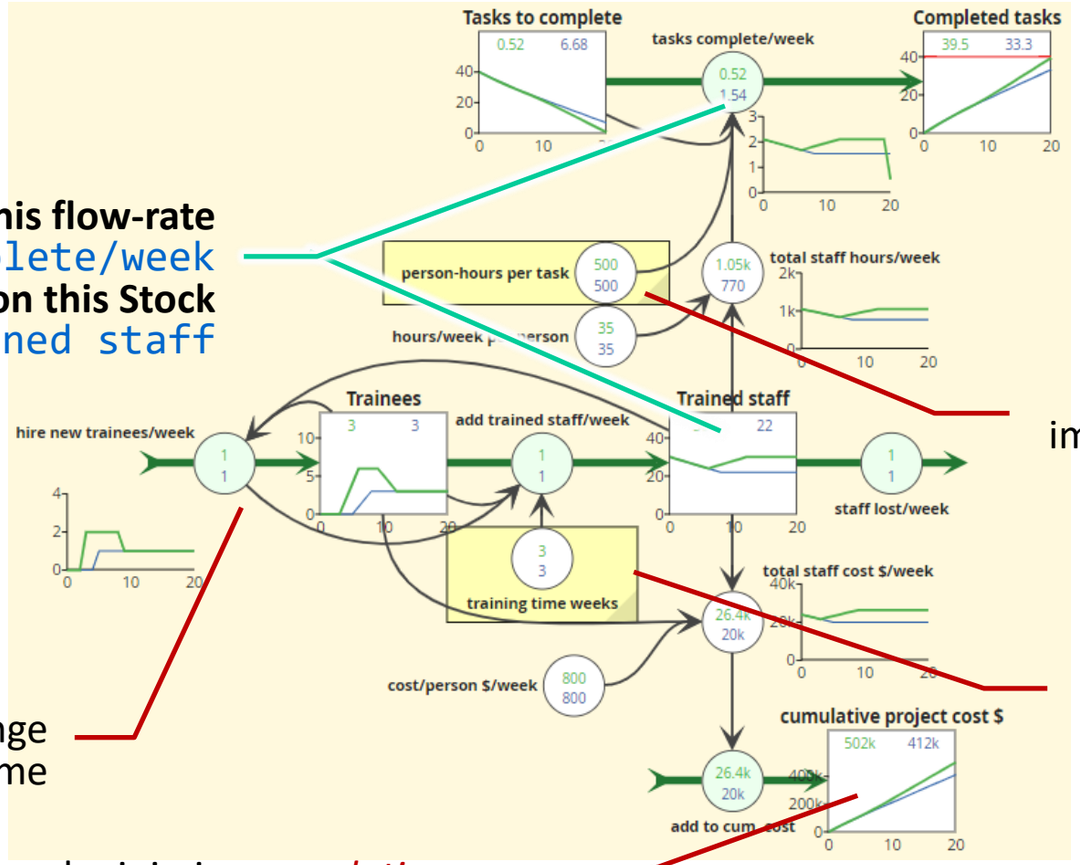

the project ends when all *tasks* are done

staff are *lost* at some rate, adding to the time to complete the project

… and staff *cost money*, including unproductive staff

In another model at sdl.re/SEstaff

# Manage the project yourself at sdl.re/SEproject (*instructions* in the model)




**Principle 4: This flow-rate `tasks complete/week` depends on this Stock `Trained staff`**

**Challenge A**. Change hiring at any time

… and minimise *cumulative cost* to complete the project in 20 weeks … or in 15 weeks

**Challenge B**. Process improvements cut *person-hours per task* to **400**

… and cut *training time* to **2 weeks**

What hiring rate now completes the project at minimum cost?

# Complications in real projects …

Errors cause ***re-work*** (in another model at sdl.re/SEstaff)

Projects have ***many parts***

… which depend on each other

And more!

***Much*** *work on SD in project management. See Lyneis, J.M. and Ford, D.N., 2007. System dynamics applied to project management: a survey, assessment, and directions for future research. System Dynamics Review: The Journal of the System Dynamics Society, 23(2-3).*

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# What dynamic models add

Quantified simulation – a ***digital twin*** of reality (*everything matches the behaviour of real-world elements*)

Physical ***and organisational*** parts of the system (*staffing, products/services, customers/channels, and financials !*)

***Wide scope*** – SE models already deal with physical cases … now add cross-functional and behavioural factors

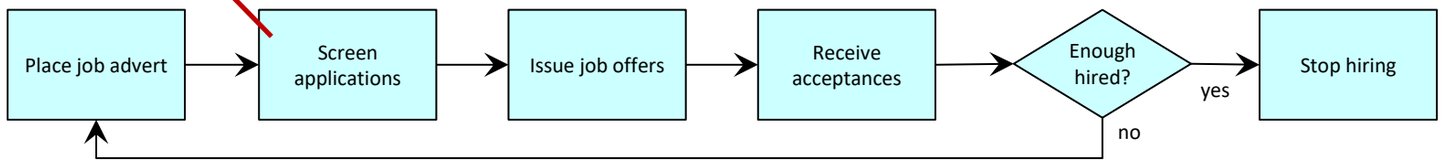
Operational ***and*** strategic time-scales

Most causes of ***complexity*** – stock-accumulation, interdependence, feedback, thresholds , intangibles, tipping points

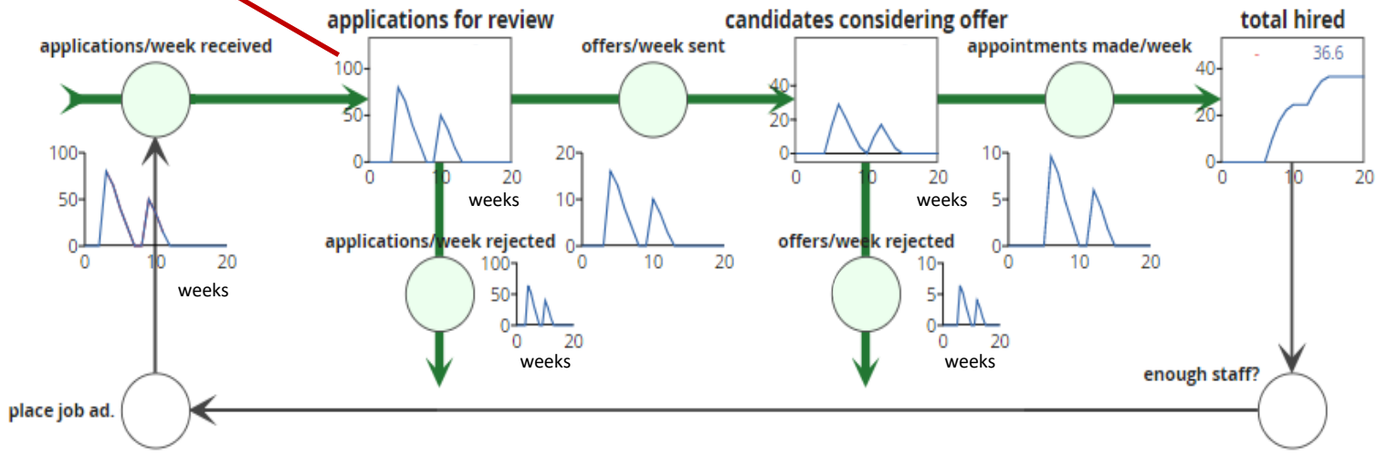
System dynamics can handle all these mechanisms, quantitively

# Dynamic modeling goes beyond process mapping – with quantified simulation

the activities that are *done* to the 'things' in the system … *qualitative*, ***verbs*** !




how *the 'things' themselves* change over time … *quantitative*, ***nouns*** !




Try it yourself at
sdl.re/HiringProcess

# Modeling mixed physical ***and*** enterprise systems …

A large-scale mixed physical/non-physical project-model
– a tidal power station and water-quality project

… at sdl.re/LakeModel



*… courtesy of Copernicos Groep*

# An operational ***and*** strategic issue – customer-support staff for an insurance business

The business has ~500,000 *customers*

… a % of customers *call each month*

… *support-staff* handle daily calls

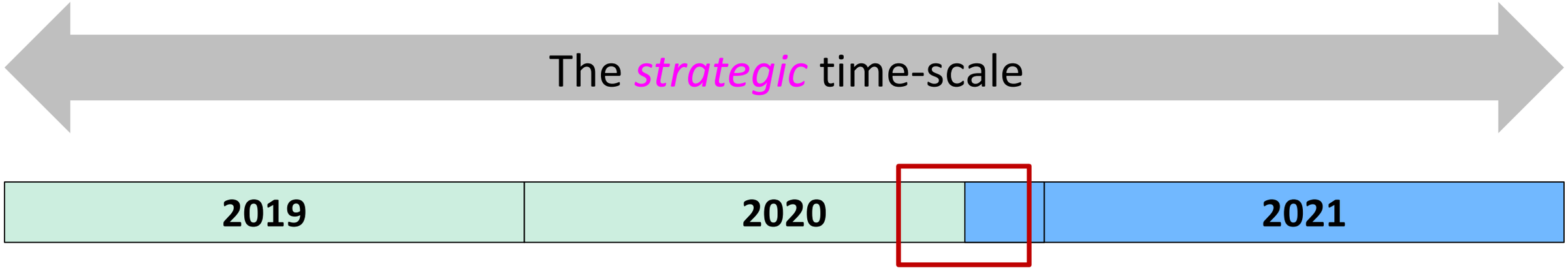
… under-staffing causes *overload* and more-than-normal *lost customers*

… a staff shortage triggers *a hiring process*

… the staff target can include a *% uplift* to handle *peak call-rates*

And we may need optional *extra hiring* episodes

# The operational -v- strategic view of customer-support staffing in insurance

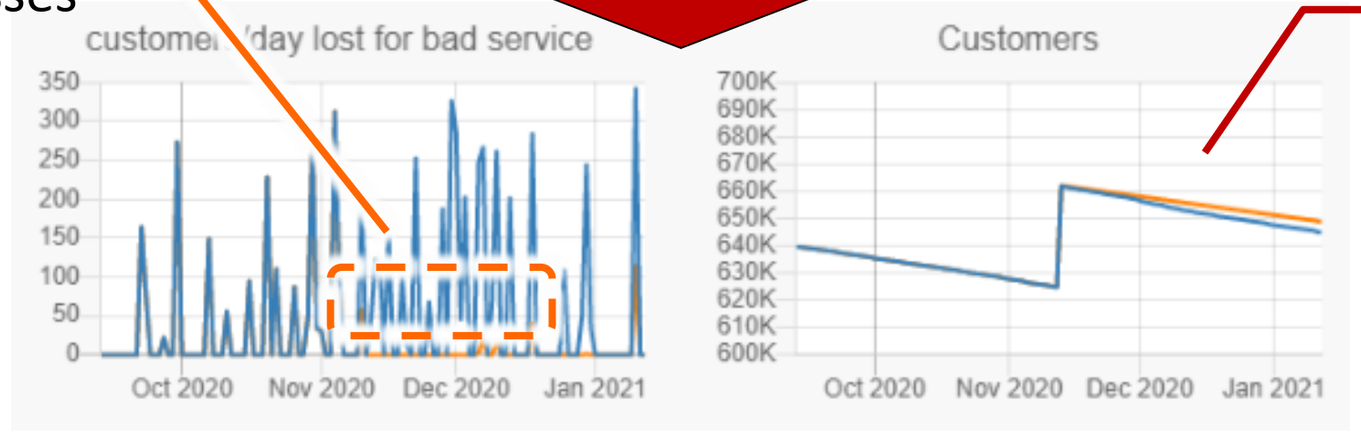


# Avoid work overload and high customer-losses with a short-term hiring campaign …

daily progress of applicants through the hiring process




the higher staffing cuts the excess customer losses

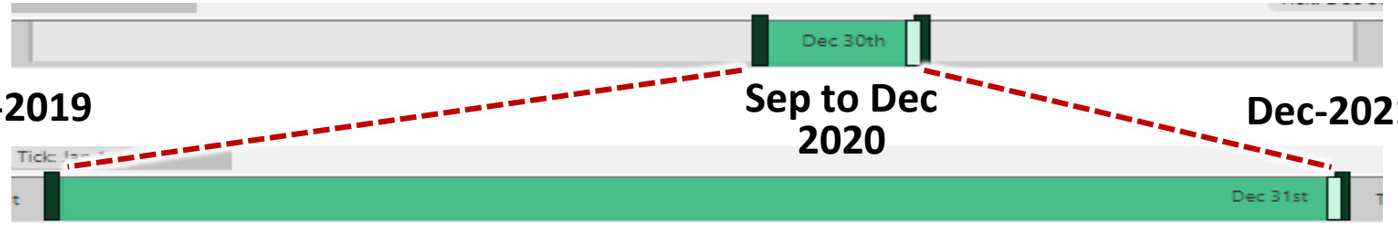



… and we retain more of the customers won by the campaign

Get this model at
sdl.re/StaffingDigitalTwin

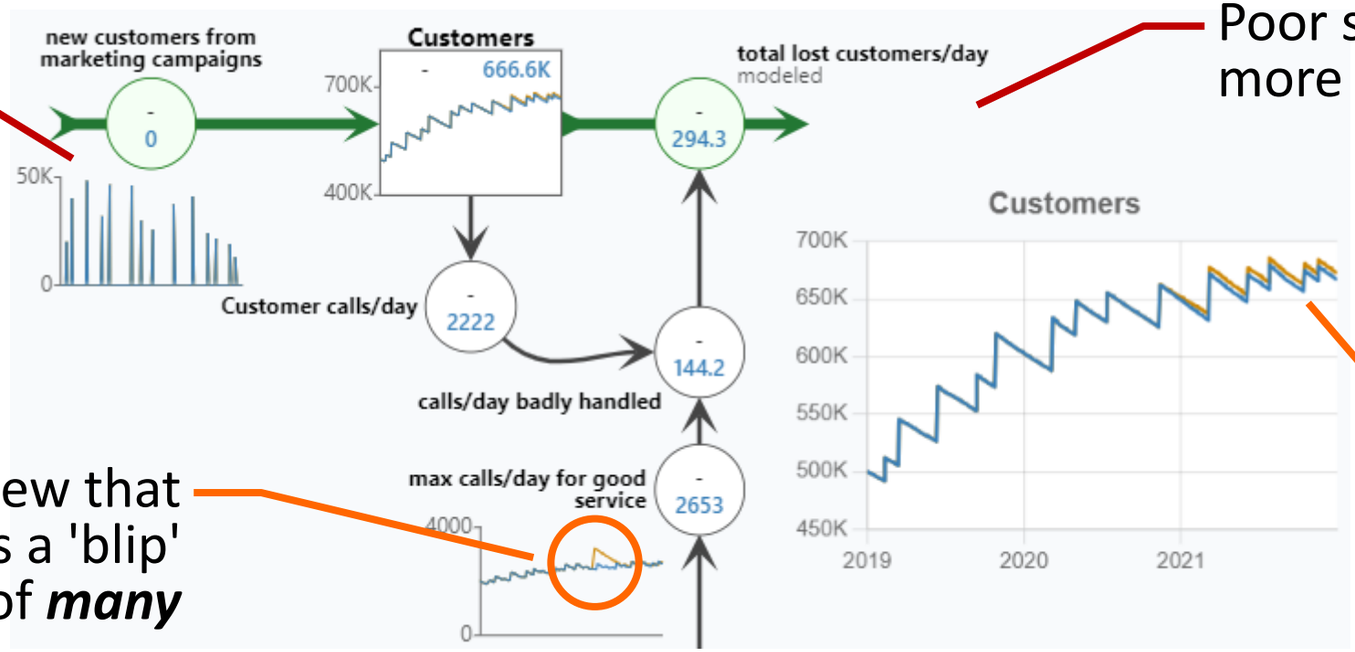
# A ***strategic*** view of the same staffing challenge

"***Zoom out***" our view of the time-scale …




Each marketing campaign wins customers

Poor service ***loses*** more customers




On a ***strategic*** view that hiring campaign is a 'blip' – one of ***many***

but the retained customers ***carry over*** – for every such episode …

[ from the staffing model ]

# The fast, reliable AgileSD 4-step process
(*differs from conventional methods, see* sdl.re/AgileSD)

System Dynamics Society

1. Time-chart the desired outcomes (*and history*)

   "*what causes those outcomes?*"

2. Find, specify, quantify the "stocks" of resources driving those outcomes (*customers drive sales; staff drive service support, etc …*)

3. Quantify the rate of gains and losses causing those resource-stocks to grow or decline

   "*what causes those gains and losses?*"

4. Find, specify, quantify the other resource-stocks causing those gains and losses

… repeat until satisfied

Simple, concrete – "*I can calculate A from B and C*"

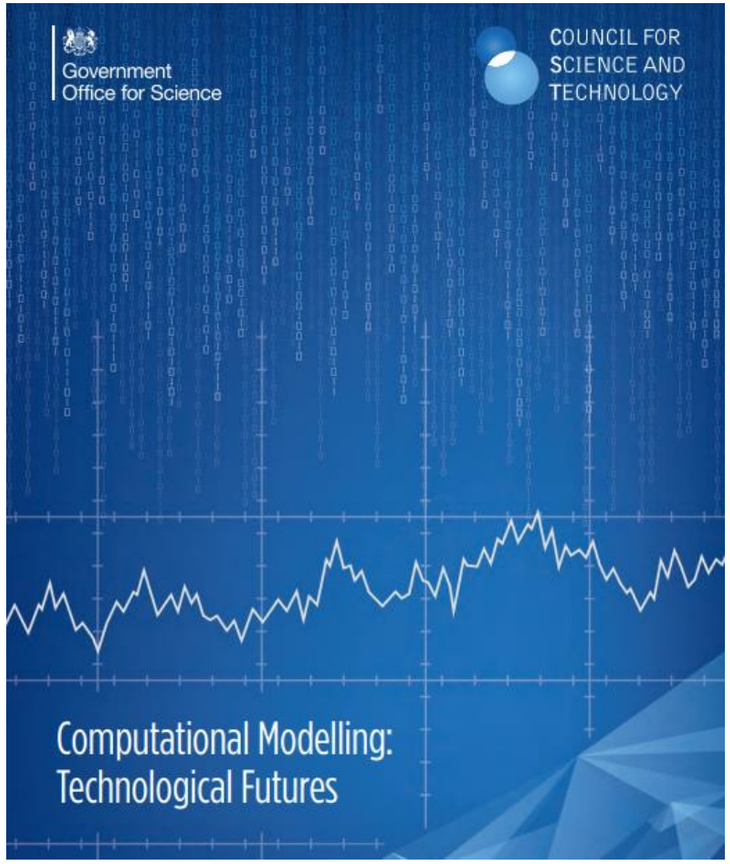
A universal feature of all real-world systems

add a highly visual, quantifying simulation tool

… a living, dynamic (time-based) model that mimics the real-world system and its behaviour

# The UK Govt thinks there's a big opportunity for model-supported strategy and decision-making …

… because it is now practical to simulate any episode, project, initiative, enterprise (*business or other*).




GOV.UK

Home > Business and industry > Science and innovation

Research and analysis

**Computational modelling: Blackett review**

Review of UK computational modelling capabilities.

From: Government Office for Science and Council for Science and Technology
Published 20 February 2018

Computational modelling: technological futures

# Next steps

Get the ***slides*** sdl.re/sds08slides

3 LinkedIn articles sdl.re/LIPSESD1 , 2, 3

For system dynamics expertise on SE, contact the Asset Dynamics interest group.

Other business modeling resources

Modeling Performance Improvement Programs – a short course

Business Dynamics Modeling Core classes (*includes a low-cost 'essentials' option, and for ⅓ discount, enter **blog33** at checkout*)

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