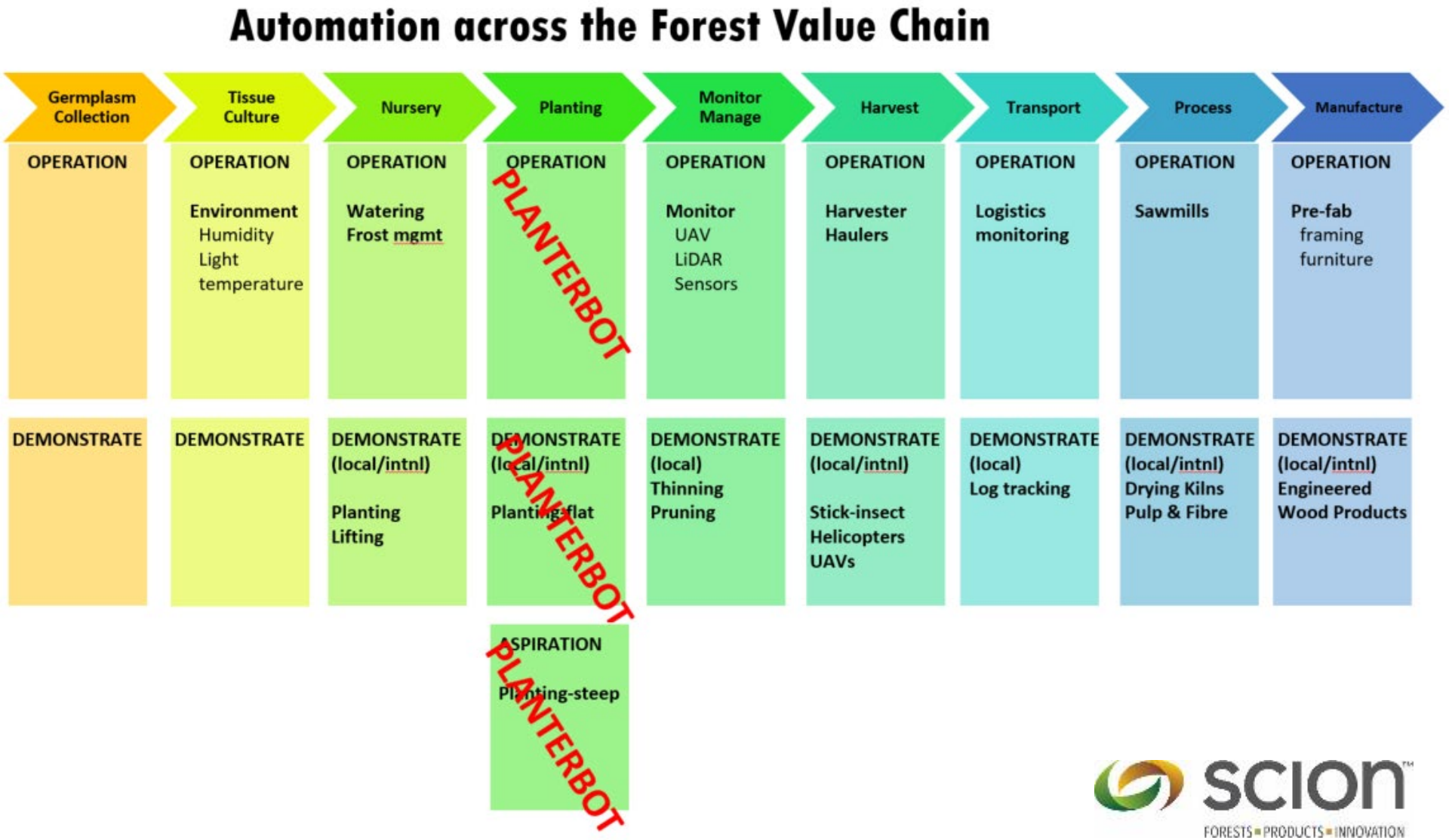
Planterbot Logistics & Economics

Context – Technology Application and Development



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Value Chain Logistics

Logistics factors must be incorporated into the design.

Pre-Planting	Seedling Suppliers	Current capital investment is utilised
	Capacity of Supply	Currently some nurseries 5-7mil seedlings/year
	Timing of supply	Material is available across a wider planting window
	Transportation of plants	Transportation changes due to increased need for stock and steep land access
	Delivering fuel to site	Phase 1 : Diesel
On Site	Distance Travelled	Network links, Wifi, GPS
	Maintenance	Scheduled and unexpected – self diagnosis, human support
	24/7 Operations	Technical Support
	Restocking	Re-supply of planterbot
	Refuelling	Refuelling (how, when)

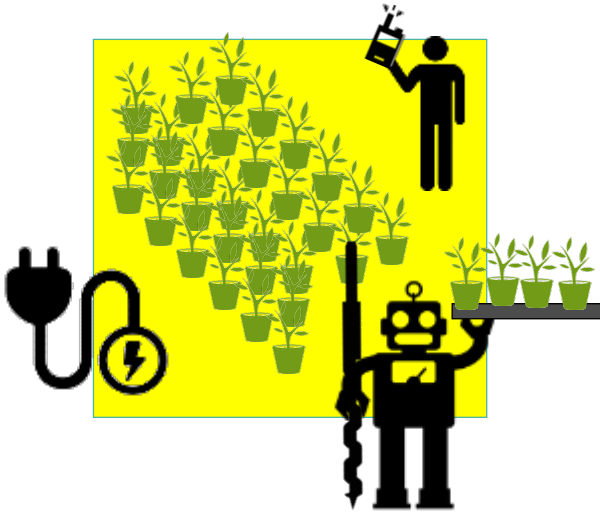
Critical Step:

Logistics modelling informs the design criteria.

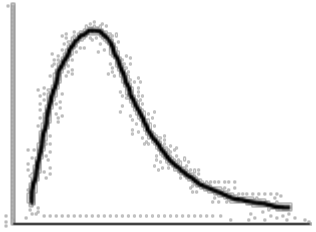
- **Discrete Event Simulation:** Model the Value chain.
- **Economic Modelling:** Remove economic assumptions.

Operations

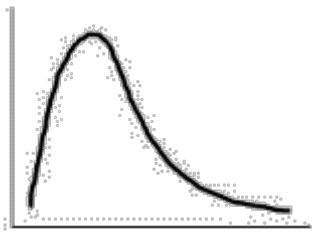
Not Simulated

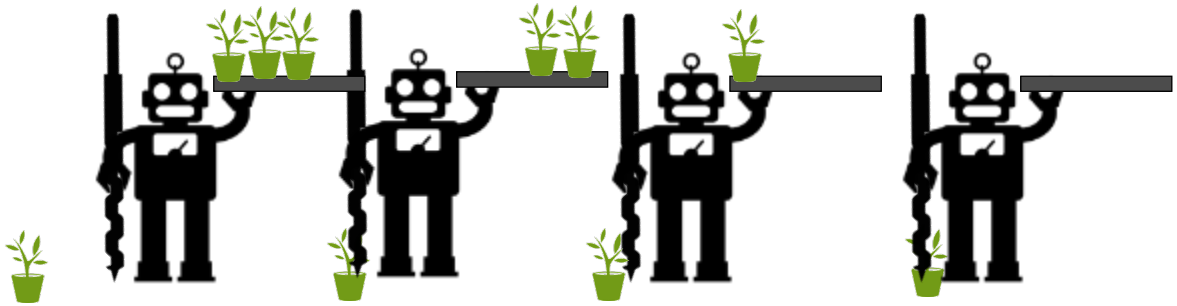


Moving Time



Planting Time





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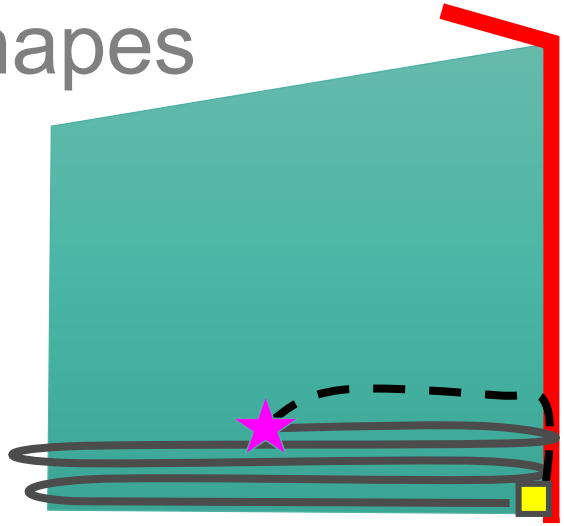
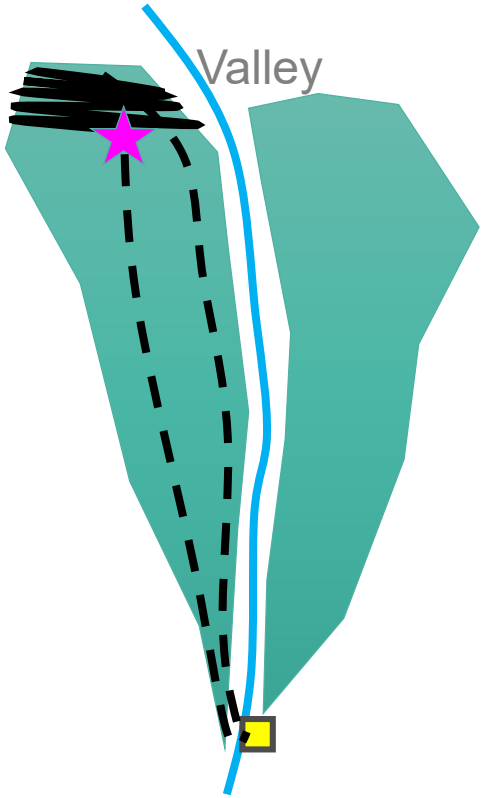
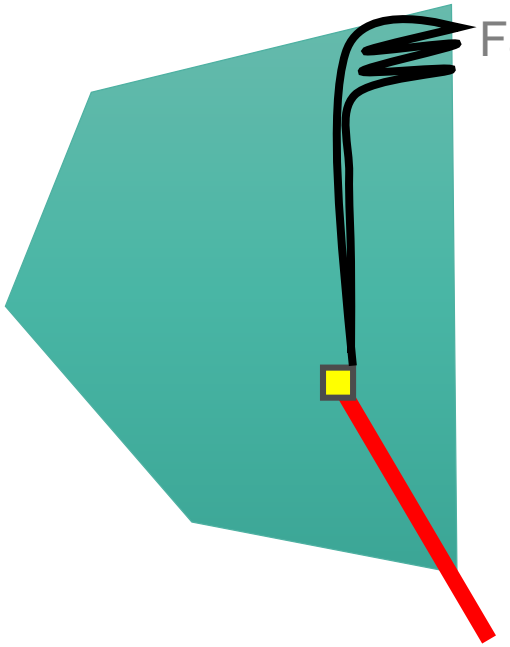
Forest Shapes



Commercial Block



Valley



Farm Block

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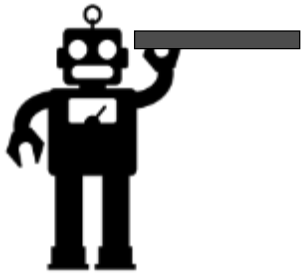
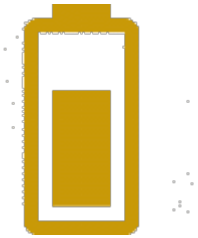
Critical Components

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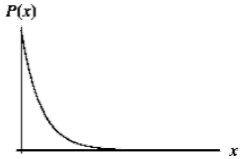
P(f)=0.02


Shifts

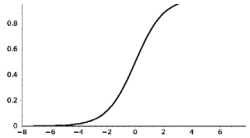

Maintenance


Recharge

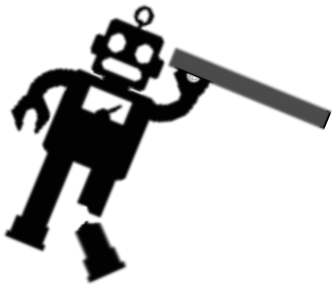

Sharpening
(Replacements)
n=500



Post Maintenance


Pre Maintenance

Random P(b)=0.001


Breakdowns


Lifespan


Breakages
P(b)=0.003

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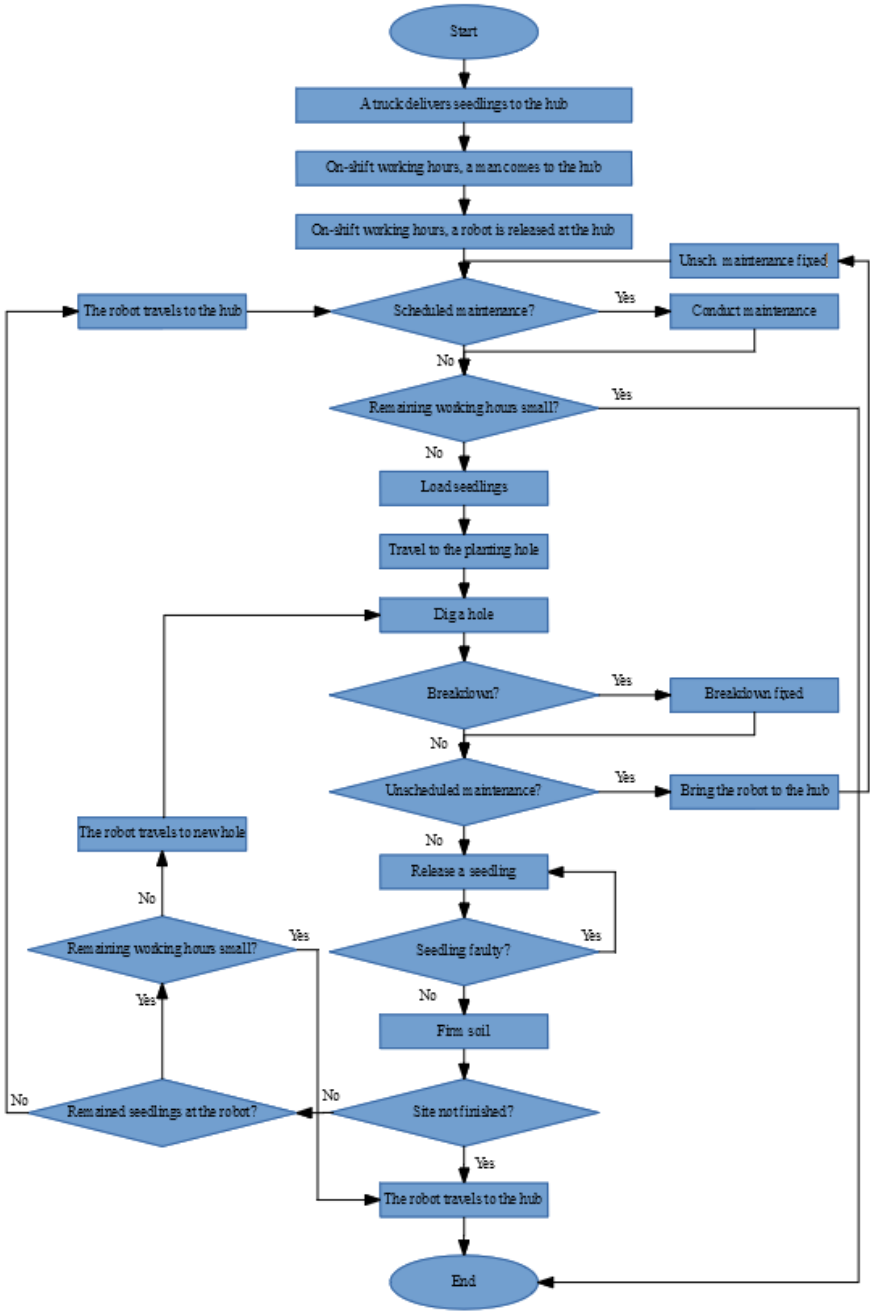
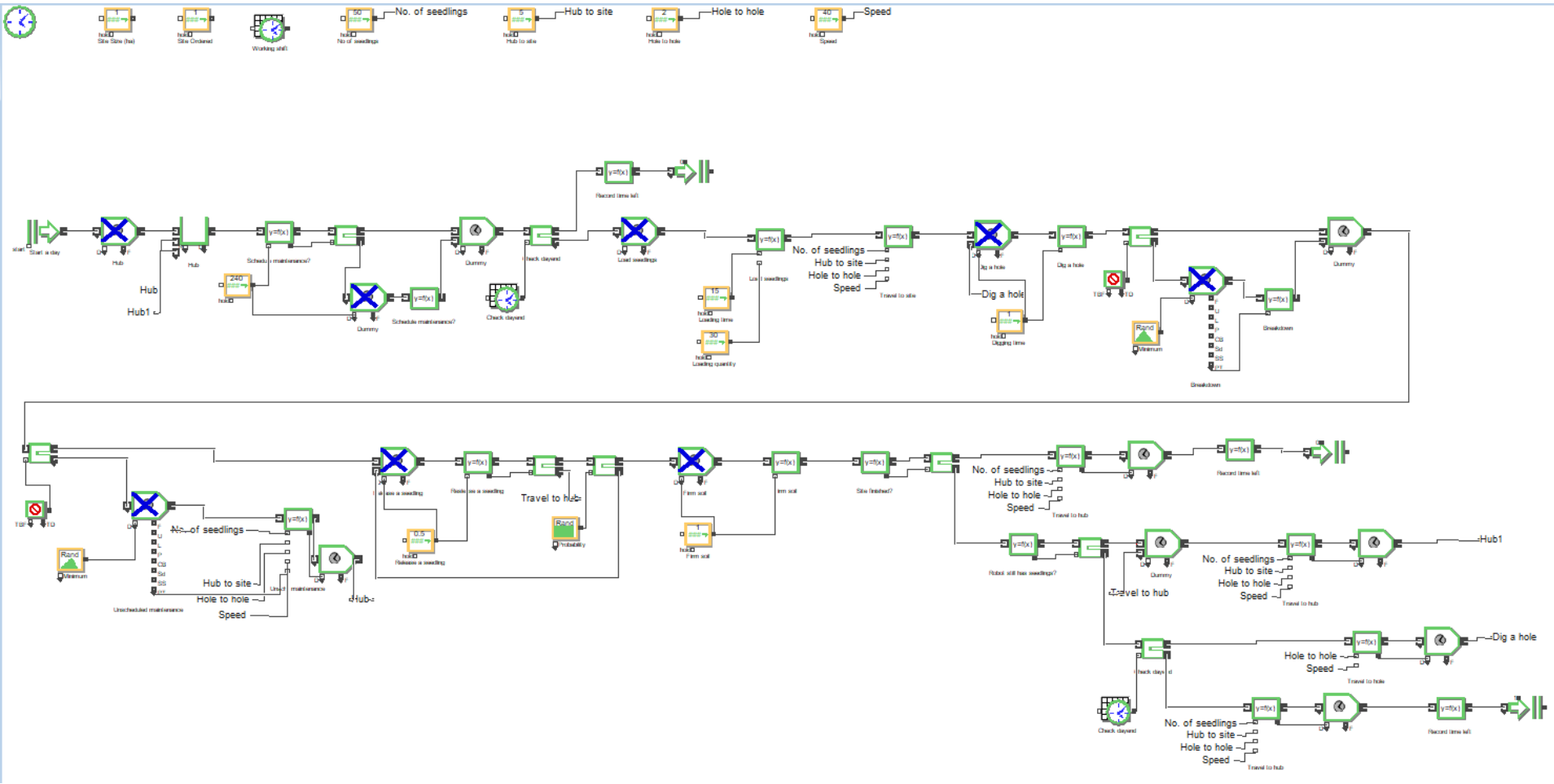
Planterbot Discrete Event Simulation (DES) Logistics Model



Planterbot Logistics Model – Gen 0



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Planterbot Logistics Model – Gen 0

Assumptions:

- Standard working hour: 08:00 – 12:00, 13:00 – 17:00
- Scheduled maintenance after 2400 working minutes (40 hours) and takes 4 hours for maintenance.
- Planting area: rectangle
- Planting size: 4 hectare = 40000 m2 (100m x 400m)
- Distance between holes: 2m. Planned planting: 50 seedlings/row x 200 rows. Total seedlings for the area: 10000 seedlings
- Distance from the hub to the first hole: 5m
- PlanterBot speed: 40m/minute
- Loading capacity: 30 seeds

Planterbot Logistics Model – Gen 0

Row Labels	Duration (min)	Duration (%)
Digging	70,347.00	18.90%
Firm soil	69,031.00	18.55%
Loading seedlings	52,950.00	14.23%
Release a seedling	36,292.00	9.75%
Traveling to hole	3,341.35	0.90%
Traveling to hub	14,517.58	3.90%
Traveling to the site	22,166.30	5.96%
Breakdown	38,685.77	10.40%
Unscheduled maintenanc	32,424.77	8.71%
Scheduled Maintenance	32,400.00	8.71%
Grand Total	**372,155.77**	**100.00%**

- Results
  - Total tree planted: 69031 trees
  - Total working hour: 6203
  - Tree planted/hour: 11
  - Tree planted/year: 34516
  - Machine working hour: 5122
  - Diesel used: 30 lit/hour
  - Total diesel used: 153,665 lit

Note: Total simulation time: 2 years, equals to 6203 hours. This total working hour 6203 > "standard working hour" 5840 because at some days, the machine may take some minutes overtime to finish a task. E.g., the machine knows that it is nearly the end of the day, and travels from the site to the hub from 16:50 to 17:05. In this case, I calculate the working time for this traveling task takes 15 minutes, while "standard working hour" thinks it is only 10 minutes

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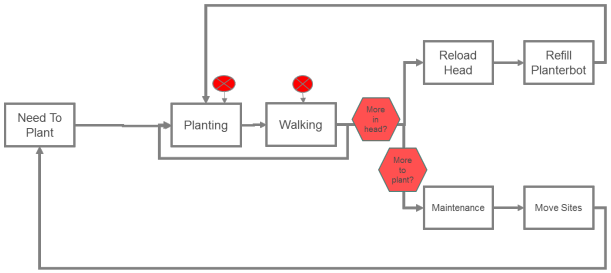
Planterbot Economic Model Inputs – Users can change it



From the DES logistics model

- Number of seedlings planted
- Planterbot Utilisation (uptime)
- Worker Utilisation (uptime hours)
- Worker utilisation (contracted hours)
- Diesel use
- Number of site shifts

Outputs sent to Economic Model

Basic Economic Inputs

Capital costs

- Planterbot
- Other Capital

Replacement year (5-20)

Tree cost (delivered)

From the logistics model

Yield (Tree/hour, tree/year)

Labour Cost

Fuel cost

Benefits

Planted tree value –> Profit

Cost of the previous generation -> Saving

Forested area value -> Opportunity benefit

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Planterbot Economic Model Operations

Profit = Total planted tree value – total costs

Cost reduction = Earlier gen costs – current costs

Opportunity benefit = Benefits of the additional afforestation – costs

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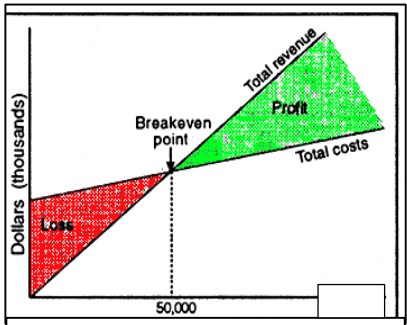
CASHFLOW

Basic outputs
Cost/planted tree
Net Present Value
Return on Investment (ROI)
Payback period (1/ROI)
Internal Rate of Return (IRR)
Further outputs
Sensitivity analysis (cost of one planterbot, hourly planted trees, fuel consumption)
Break even of a planterbot cost
Break even of a planted tree value
Considering opportunity cost (otherwise empty fields), only the value of the afforestation considered, no carbon, no forestry included
Considering uncertainty in plant, planterbot costs and planted tree value



https://www.boxtheorygold.com/blog/bid/29553/do-you-know-your-sales-break-even-point

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General project assumptions

Planterbot cost	150,000
Project evaluation period	20
Required mininum pre-tax risk premium on invested capital	6%
Percentage of loan from total investment	60%
Loan interest rate (inflation+)	2.0%
Loan term	10
Deposit interest rate	0.5%
Discount rate	6.0%
Inflation	1.8%
Income tax rate	35%
Standard operating days/year	351

Capacity

	Yearly planted trees
Planterbot capacity (tree/year planted)	34,516

Depreciation, replacement, maintenance

Years of depreciation (MACRS)	7
Replacement year	20
Maintenance %/ year	2.0%
Capital maintenance %/ year	1.5%

Feedstocks

	Cost/tree ($)	Reject	Cost/year ($)
Plant	1	15.0%	40607

Labour

	Hourly rate (all cost included) ($/hour)	Hour/year	Cost/year ($)
Labour	25	3102	77538

Fuel costs

Energy source	Quantity	Cost ($)	Total cost
Gasoline (l)	76833	1.65	126774
Total			126774

Value generated

	Value $/piece	Total value ($)
Planted tree	12	414,192

Summary of Financial Measures

1,623,020	NPV
59%	IRR
61%	ROIC
1.10	Payback period
7.94	Cost/planted tree ($)

Cost of planting tree/planted tree ($ and %)

3.67	46.2%	Fuel
2.25	28.3%	Labour
1.00	12.6%	Plant
0.63	7.9%	Depreciation
0.15	1.9%	Maintenance
0.13	1.6%	Other
0.11	1.4%	Overhead
7.94	100.0%	**Total**

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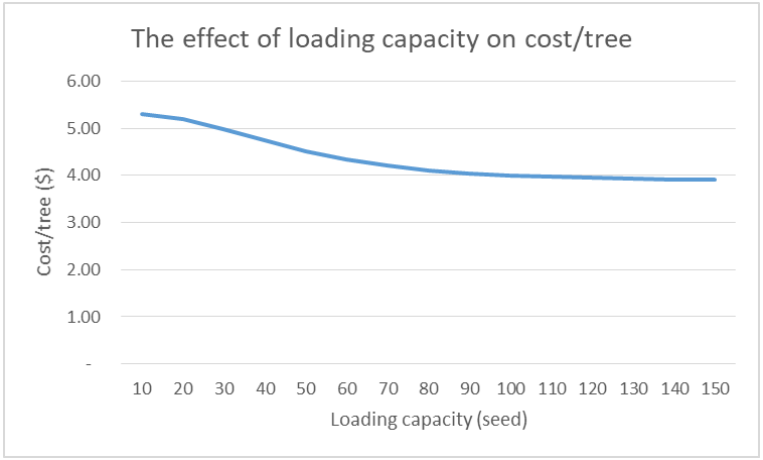
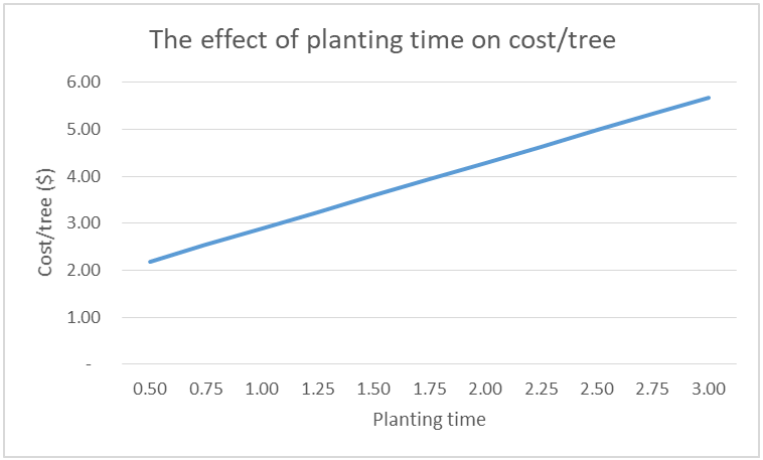
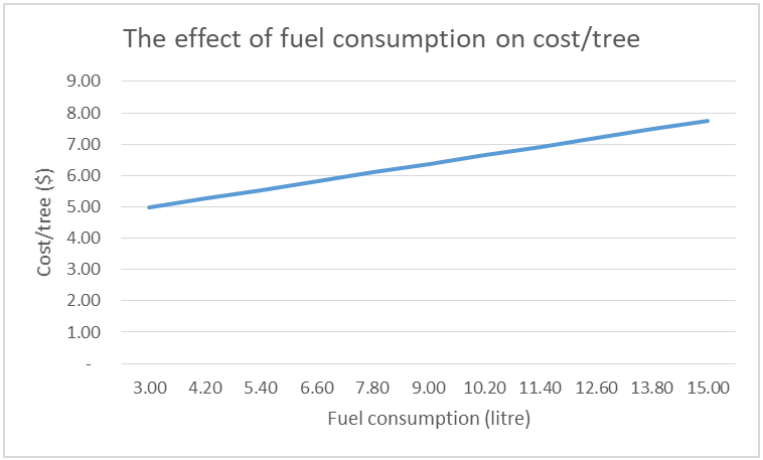
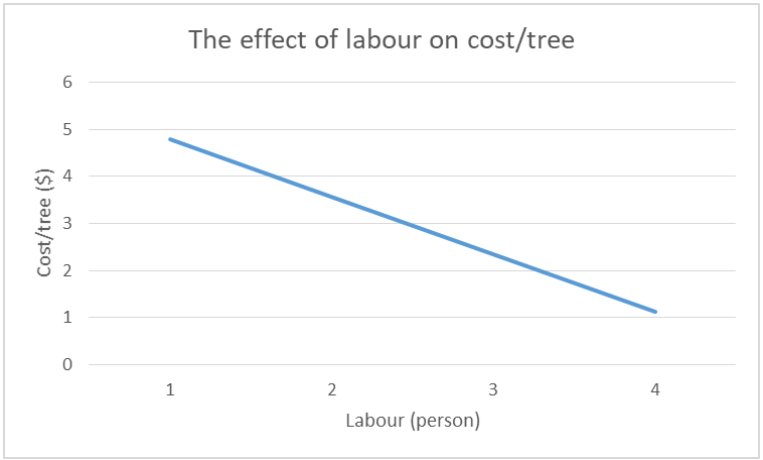
Results









Seedlings pickup effect: cost/tree = 3.858861 + (1.465089)/(1 + (pickup number/46.11837)^2.837092)
Planting time effect: cost/tree = 1.492 + 1.396*planting time
Fuel consumption effect: cost/tree = 4.3 + 0.23*hourly fuel consumption
Number of 1 technician supported planterbot effect: cost/tree = 6.007 - 1.22*number of supported planterbots

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Comparable

- A work from Hock et al. (2014) estimated that the cost of planting a tree is around 1.2.
- This estimation based on interview with industrial partners in a specific context

Sensitivity Analysis											
Case	1	2	3	4	5	6	7	8	9	10	All the best
Fuel consumtion (l/h)	3	3	3	3	3	3	6	9	3	3	3
Technician supported robots	1	1	1	1	1	1	1	1	2	3	3
Planting time	2.5	2.5	2.5	2.0	1.5	1.0	2.5	2.5	2.5	2.5	1.0
Number of seedlings/pickup	30.0	60	90	30	30	30	30	30	30	30	90
Total labour hours/year	6183	6054	6076	6266	6300	6409	6183	6183	3092	2061	2136
Total number of trees/year	44258	50161	53924	52407	62940	79552	44258	44258	44258	44258	79552
Total fuel consumption/year	18549	18162	18228	18798	18900	19227	37098	55647	18549	18549	19227
Cost/tree planted	4.99	4.33	4.05	4.27	3.59	2.89	5.68	6.37	3.16	2.55	1.47

Slope	Description	Year 1 (ha^{-1})
0 - 5	Flat	1,081.42
5 - 15	Rolling	1,114.95
15 - 25	Steep	1,193.20
> 25	Very Steep	1,403.35

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Minimum requirements for planterbot design

- A NZ benchmark what is $1.2-$2 /tree planted,
- Sensitivity analysis was performed and we have defined the regressions to know the importance and effect of the factors
- The following constraints to meet with the benchmark costs:
  - **One technician should support the planting ~80,000 tree/year to keep the labour costs down;**
  - **The fuel consumption should be below 0.25 l/planted tree;**
  - **Planting time should be below 1 minute/tree excluding pickup time, maintenance and all breaks;**
  - **The cost of the planterbot is not a key factor up to $100,000**;

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Prosperity from trees *Mai i te ngahere oranga*

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