FoxholeManuGen

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October 7, 2025

1 Introduction

Within Foxhole, one of the primary ways to manufacture new items is through the Factory. This involves a truck getting materials either from the Refinery or crates at a Seaport/Storage Depot and ordering a number of items from the Factory. There are 7 categories of items and a player may start exactly 1 queue in each category. Each queue can contain 0-4 orders of crates that can be any item within the category. Every item has its individual material and time costs associated with it and any materials leftover will be returned. Thus, an optimisation problem is born.

This is related to a process known as *facdancing* and in this document I hope to explore the process behind it.

2 Preface

I cannot emphasis this enough; there is very little practical use for such an endeavour. As the title suggests, this is LARP to the highest degree but it is a fun mental exercise. This document hopefully will grow in scope as I work on it more and more but at the beginning, it will be fairly bare-bones in terms of relevance. I think the ultimate product of such a project would be an algorithm that FMAT could use for *Thread Manufacturing*, that is, having an event where a certain manufacturing goal is set and a certain number of people sign up. The algorithm will then calculate the most efficient manufacturing sequence (in both materials and time) for each individual person, essentially "multi-threading" to get to the goal as best as possible.

The obvious should be stated here; maximum efficiency is ultimately fairly irrelevant to facdancing. More time and effort will probably be spent solving this problem than it would ever save.

3 Problem Statement

This will be a general problem statement for all stages of the project and will probably be heavily refined over time. Some assumptions may move from specific stages to the general problem statement and vice versa. This document will use general variables (there are a lot I'm sorry) and if there are known constants then it will be denoted (e.g. stack values for all materials are 100).

Consider a set of items S that contains all items that can be manufactured at a Factory.

$$S = \{x : x \ can \ be \ manufactured \ at \ a \ Factory\}$$

S is then partitioned into $n_c = 7$ disjoint categories. In this document,

$$\vec{c} = \Big[SmallArms,\ HeavyArms,\ HeavyAmmunition,\ Utility,\ Medical,\ Resources,\ Uniforms\Big]$$

There are $n_m = 4$ material types that each have a crate value and stack value. For a material m, the crate and stack value will be denoted as m_c and $m_s = 100$. In this document,

$$\vec{m} = \Big[BMats,\ EMats,\ HEMats,\ RMats\Big]$$

A single item to be produced will be called an *order* (e.g. 1 order of 9mm will produce 1 crate). Each item has its individual material cost and time cost. For item x, this will denoted as row vector $\overrightarrow{x_m}$ and x_t respectively. For example, if we consider the Clancy-Raca M4, then $\overrightarrow{x_m} = \begin{bmatrix} 250 & 0 & 0 & 25 \end{bmatrix}$ and $x_t = 250$.

A single category to be produced will be called an *queue*. A queue can contain $[0, n_{o_{max}}]$ (where $n_{o_{max}} = 4$) orders of any item as long as it belongs in the category. A category can be represented as a category cost matrix and category time vec, S_{mi} and $\overrightarrow{S_{ti}}$ respectively.

$$S_{mi} = \begin{bmatrix} \vec{x_1} \\ \vec{x_2} \\ \dots \\ \overrightarrow{x_{|S_i|}} \end{bmatrix}, \ \overrightarrow{S_{ti}} = \begin{bmatrix} x_{t1} \\ x_{t2} \\ \dots \\ x_{ti} \end{bmatrix}$$

A queue can be represented by a row vector that will be named the queue vector $\overrightarrow{C_S}$, which will denote which items to order from a category and how many. The resulting cost of the queue vector will be denoted as $\overrightarrow{C_{Sm}}$ and C_{St} for materials and time respectively.

$$0 \leq \sum_{i=1}^{n} C_{Si} \leq n_{o_{max}}$$

A single trip to the factory will be called a *batch*. A batch can be represented with n_c category choice vectors. A batch may have in total $[0, I]$ (where $I = 15$) orders in total. For batch B, its total material cost will be denoted as B_m.

$$0 \leq \sum_{i=1}^{n_c} (\sum_{j=1}^{n} C_{ij}) \leq I$$

$$\overrightarrow{B_m} = \sum_{i=1}^{n_c} (\overrightarrow{C_{S_i}} \times S_{mi})$$

An *n-batch* will be defined as a batch with queues from only the first n categories according to $\vec{c}$, while an *n-group* will be defined as a batch with queues from any n categories.

This document will work with the assumption that every order will be made with a truck of inventory size $I = 15$ and inventory $\overrightarrow{I_m}$. All examples and considerations will also use the Warden faction items.

3.1 TODO: extend to sequences (collection of batches) and finish problem statement

4 Example 1

That's a lot of vectors and matrices so let's reground this in Foxhole. We'll do an example with only the Heavy Ammunition category.

Let the Heavy Ammunition category be set S.

Let $x_1 = 68$mm, $\overrightarrow{x_{m6}} = \begin{bmatrix} 120 & 240 & 0 & 0 \end{bmatrix}$.

Let $x_2 = 250$mm "Purity" Shell, $\overrightarrow{x_{m4}} = \begin{bmatrix} 120 & 0 & 100 & 0 \end{bmatrix}$.

Let $x_3 = 120$mm, $\overrightarrow{x_{m2}} = \begin{bmatrix} 120 & 0 & 10 & 0 \end{bmatrix}$.

Let $x_4 = 150$mm, $\overrightarrow{x_{m3}} = \begin{bmatrix} 120 & 0 & 60 & 0 \end{bmatrix}$.

Let $x_5 = 40$mm, $\overrightarrow{x_{m5}} = \begin{bmatrix} 160 & 240 & 0 & 0 \end{bmatrix}$.

Thus, the category cost matrix will be,

$$S_m = \begin{bmatrix} 120 & 240 & 0 & 0 \\ 120 & 0 & 100 & 0 \\ 120 & 0 & 10 & 0 \\ 120 & 0 & 60 & 0 \\ 160 & 240 & 0 & 0 \end{bmatrix}$$

Note that this matrix is static and will not change throughout calculations (until the devs update something). Every category cost matrix can be found in Appendix A.

If we wanted to queue one 68mm, one 250mm and two 120mm then,

$$\overrightarrow{C_S} = \begin{bmatrix} 1 & 1 & 2 & 0 & 0 \end{bmatrix}$$

To get the cost we simply multiply both matrices.

$$\overrightarrow{C_{Sm}} = \begin{bmatrix} 1 & 1 & 2 & 0 & 0 \end{bmatrix} \times \begin{bmatrix} 120 & 240 & 0 & 0 \\ 120 & 0 & 100 & 0 \\ 120 & 0 & 10 & 0 \\ 120 & 0 & 60 & 0 \\ 160 & 240 & 0 & 0 \end{bmatrix}$$

$$\overrightarrow{C_{Sm}} = \begin{bmatrix} 480 & 240 & 120 & 0 \end{bmatrix}$$

In other words, it will cost 480 BMats, 240 EMats and 120 HEMats.

5 State Space

Obviously, much of the complexity will rely on the size of the state space. Let the set of all queues be Q. For any given category S, the set of all possible queues for S will be denoted as Q_S.

Q_S is then partitioned into $n_{o_{max}+1}$ disjoint sets representing each possible queue for a number of orders denoted.

For example, the set $Q_{SmallArms_2}$ is the set of all queues where only two items are ordered from the Small Arms category.

We can calculate the size of a given subset as:

$$|Q_{S_{n_o}}| = \binom{|S| + n_o - 1}{|S| - 1}$$

And thus the size of Q_S as a whole:

$$|Q_S| = \sum_{i=0}^{n_{o_{max}}} |Q_{S_i}|$$

Taking the Heavy Ammunitions category as an example,

$$|Q_{HeavyAmmunition_0}| = \binom{5-1}{5-1} = 1$$

$$|Q_{HeavyAmmunition_1}| = \binom{5+1-1}{5-1} = 5$$

$$|Q_{HeavyAmmunition_2}| = \binom{5+2-1}{5-1} = 15$$

$$|Q_{HeavyAmmunition_3}| = \binom{5+3-1}{5-1} = 35$$

$$|Q_{HeavyAmmunition_4}| = \binom{5+4-1}{5-1} = 70$$

So if you want to order zero items from Heavy Ammunition then there is 1 possibility, 5 possibilities for only one order, 15 possibilities for only two orders, 35 possibilities for only 3 orders and 70 possibilities for all 4 orders. Thus, there are $|Q_{HeavyAmmunition}| = 1 + 5 + 15 + 35 + 70 = 126$ possible queues Heavy Ammunition.

Doing this for all categories:

$$|Q_{SmallArms}| = 23751$$
$$|Q_{HeavyArms}| = 14950$$
$$|Q_{HeavyAmmunition}| = 126$$
$$|Q_{Utility}| = 14950$$
$$|Q_{Medical}| = 126$$
$$|Q_{Resources}| = 5$$
$$|Q_{Uniforms}| = 715$$

Thus, $|Q| = 23751 \times 14950^2 \times 126^2 \times 5 \times 715 = 3.01 \times 10^{20}$ (3 sig figs).

That's a lot of possible batches. Obviously most of these will be ruled out by one consideration or another (mostly inventory size).

6 Cost Metrics

There are multiple ways to consider a cost vector as optimal as a result of game mechanics. For example, if you prefer to scroop your own materials and manufacture from the Refinery, you can easily retrieve materials in stacks of 100. However, if you prefer to use crates of materials, you are beholden to their crate values.

Given a cost vector $\vec{C}$, it is defined as *n-valid* if:

$$\sum_{i=1}^{n_m} \left\lceil \frac{C_i}{C_{si}} \right\rceil = n \tag{1}$$

Let the set of batches that are n-valid be V_n.

A cost vector is defined as *affordable* if it is n-valid for any $n \leq I$. Let the set of affordable cost vectors be A.

$$A = \bigcup_{i=0}^{I} V_i \tag{2}$$

A cost vector is defined as *stackable* if it is affordable and:

$$\forall m \in \vec{C},\ m \mid m_s$$

Let the set of stackable batches be ST.

A cost vector is defined as *perfectly stackable to p* if it is stackable and p-valid. Let the set of perfectly stackable batches to p be PST_p. If a certain category is to be included in the batch, it will be denoted as $PST_{p,C}$. For example, if we want the set of perfectly stackable batches to 15 that include the Small Arms category, it would be denoted as $PST_{15,SmallArms}$. If a certain number of categories is to be included, it will be denoted as $PST_{p,n}$. If no p is specified when talking about perfectly stackable batches, then assume the statement for either all p or $p = I$ depending on the context.

Perfectly stackable batches describe optimal cost vectors for manufacturers who get their materials from a Refinery.

A cost vector is defined as *crateable* if it is affordable and:

$$\forall m \in \vec{C},\ m \mid m_c$$

Let the set of crateable batches be C

A cost vector is defined as *perfectly crateable to p* if it is crateable and p-valid. The same notations from perfectly stackable batches will apply for perfectly crateable batches as well except using PC_p instead.

Perfectly crateable batches describe optimal cost vectors for manufacturers who get their materials from crates. I will call batches/groups that are either perfectly crateable or perfectly stackable as perfect and will generalise it's notation with P_p.

7 Perfect Batches

Given a truck with inventory size $I = 15$, what are all possible batches with cost vectors that are either perfectly stackable or perfectly crateable to I.

Since perfectly stackable batches are time agnostic, we can reduce each category by material cost rather than individual items. For example, since .44 and 8mm both have a material cost of 40 BMats, we do not need to consider them as individually and can instead group them under their costs. For a category S, this reduced set will be called the material grouped category and denoted as M.

The total number of queues is thusly reduced to $|Q| = 2380 \times 7315 \times 126 \times 3060 \times 15^2 \times 5 = 7.55 \times 10^{15}$ (3 sig figs); a literal 99.99% decrease (but still a tremendous number).

To find these perfect batches, we first generate every possible queue in each category (also known as the 1-batch) and prune the unaffordable ones. Add another category into consideration to generate the 2-batch and again prune. Repeat this until we have generated the n_c-batch and thus have searched the entire state space.

At this point, it should be fairly visible that this is analogous to a classic graph traversal problem. Notably, the graph is a tree and can be trivially traversed with an Iterative Depth First Search (BFS would use too much memory).

Needless to say, this approach takes far too long. Even with pruning, there are million upon millions of paths to traverse. More damning than the runtime however, is its use-case. What is a user really going to do with a file containing every single batch? Even if you have a specific order in mind (i.e. 4 Bandages), it will still return millions of results. Also, many of these batches are totally detached from reality. It's nice to know you can perfectly order:

- 4 Clancy-Raca M4
- 1 BF5 White Ash Flask Grenade
- 1 Shrapnel Mortar Shell
- 1 Buckhorn CCQ-18
- 1 Metal Beam

- 1 Sandbag or Barbed Wire
- 1 First Aid Kit

But really, when is anybody going to manufacture this ragtag group of items? There are many such cases that are very much valid but not super meaningful. Thus, if we can define a more meaningful set of rules, we can both reduce the state space of the problem and also output more practical batches.

8 Prime Perfect Groups

Something of particular note is the repetitive nature of many generated batches. Consider an n-group that is perfectly stack/crateable to m, every single other combination of $(1, 2 \ldots m)$-group perfectly stack/crateable to $I - m$ will be repeated in the output. Instead, when we encounter such an n-group, we could instead output it alongside m and stop the search there.

These will be called *prime perfect*.

Note: In the same way that prime numbers are unique multiplicatively from natural numbers, prime perfect groups are unique additively from perfect groups.

This is to say, any prime perfect group will not have any of its respective perfect groups (either stackable or crateable) as a subset. In this method, our output is a collection of n-groups that are perfectly stack/crateable to m. The user can then pick and choose the groups they want. The state space reduction is fairly obvious, we no longer search through any batch that contains an n-group.

Appendices

A Known constants

Here is an appendix of the actual known constants within Foxhole and tables for documentation's sake.

There are 7 categories $n_c = 7$.These are:

- Small Arms
- Heavy Arms
- Heavy Ammunition
- Utility
- Medical
- Resources
- Uniforms

There are 4 material types $n_m = 4$. These are:

- Basic Materials (BMats)
- Explosive Materials (EMats)
- Heavy Explosive Materials (HEMats)
- Refined Materials (RMats)

	m_s	m_c
BMats	100	100
EMats	100	40
HEMats	100	30
RMats	100	20

Table 1: Materials and their crate & stack numbers

Shown below is every item in S by category and the costs for a single order. The S_m's and S_t's used will be as according to these tables.

There are 38 items in $S_{SmallArms}$ with 15 being Warden, 13 being Collie and 10 being neutral.

	BMats	EMats	HEMats	RMats	time(s)
Clancy-Raca M4	250	0	0	25	250
Malone MK.2	0	0	0	25	100
Booker Storm Rifle Model 838	0	0	0	15	80
Aalto Storm Rifle 24	0	0	0	15	80
No.4 The Pillory Scattergun	80	0	0	0	100
No.2B Hawthorne	70	0	0	0	60
Cascadier 873	60	0	0	0	30
A3 Harpa Fragmentation Grenade	100	40	0	0	100
Blakerow 871	140	0	0	0	80
Clancy Cinder M3	130	0	0	0	90
The Hangman 757	125	0	0	0	80
Sampo Auto-Rifle 77	125	0	0	0	70
No.1 "The Liar" Submachine Gun	120	0	0	0	80
Fiddle Submachine Gun Model 868	120	0	0	0	80
No.2 Loughcaster	100	0	0	0	70
KRR2-790 Omen	155	0	0	0	90
KRN886-127 Gast Machine Gun	0	0	0	25	100
"Dusk" ce.III	0	0	0	15	80
Catara mo.II	0	0	0	15	80
"The Pitch Gun" mc.V	80	0	0	0	80
KRR3-792	250	0	0	30	250
Bomastone Grenade	100	40	0	0	100
Fuscina pi.I	140	0	0	0	80
"Lionclaw" mc.VIII	120	0	0	0	80
Catena rt.IV Auto-Rifle	120	0	0	0	90
KRF1-750 Dragonfly	130	0	0	0	150
Volta r.I Repeater	100	0	0	0	90
Argenti r.II Rifle	100	0	0	0	70
Green Ash Grenade	140	0	0	0	100
.44	40	0	0	0	40
8mm	40	0	0	0	20
PT-815 Smoke Grenade	80	0	0	0	75
Cometa T2-9	60	0	0	0	50
7.62mm	80	0	0	0	50
9mm	80	0	0	0	50
Buckshot	80	0	0	0	50
7.92mm	120	0	0	0	60
12.7	100	0	0	0	70

Table 2: $S_{SmallArms}$ and its costs

There are 31 items in $S_{HeavyArms}$ with 10 being Warden, 9 being Collie and 12 being neutral.

	BMats	EMats	HEMats	RMats	time(s)
Willow's Bane Model 845	165	0	0	30	50
B2 Varsi Anti-Tank Grenade	95	125	0	0	80
20 Neville Anti-Tank Rifle	150	0	0	0	37
Carnyx Anti-Tank Rocket Launcher	125	0	0	15	75
Mounted Bonesaw MK.3	100	0	0	5	250
Malone Ratcatcher MK.1	100	0	0	5	125
Cutler Foebreaker	100	0	0	5	250
Cutler Launcher 4	100	0	0	35	50
Bonesaw MK.3	100	0	0	25	50
BF5 White Ash Flask Grenade	100	80	0	0	75
Venom c.II 35	100	0	0	15	50
Ignifist 30	85	70	0	0	75
KLG901-2 Lunaire F	50	0	0	15	100
"Molten Wind" v.II Flame Torch	185	0	0	25	50
Bane 45	150	0	0	40	125
"Typhon" ra.XII	100	0	0	5	125
Mounted Fissura gd.I	100	0	0	5	125
Lamentum mm.IV	100	0	0	5	125
Daucus isg.III	100	0	0	5	125
20mm	100	0	0	0	100
Cremari Mortar	100	0	0	25	50
Mammon 91-b	100	20	0	0	80
Anti-Tank Sticky Bomb	50	100	0	0	75
AP/RPG	60	150	0	0	100
ARC/RPG	60	150	0	0	100
Flare Mortar Shell	60	15	0	0	100
Shrapnel Mortar Shell	60	20	0	0	100
Mortar Shell	60	70	0	0	100
RPG	60	90	0	0	100
Tremola Grenade GPb-1	75	100	0	0	80
30mm	80	40	0	0	100

Table 3: $S_{HeavyArms}$ and its costs

There are 5 items in $S_{HeavyAmmunition}$ with 5 being neutral.

	BMats	EMats	HEMats	RMats	time(s)
68mm	120	240	0	0	200
250mm "Purity" Shell	120	0	100	0	150
120mm	120	0	10	0	55
150mm	120	0	60	0	65
40mm	160	240	0	0	200

Table 4: $S_{HeavyAmmunition}$ and its costs

There are 25 items in $S_{Utility}$ with 4 being Warden, 3 being Collie and 18 being neutral.

	BMats	EMats	HEMats	RMats	time(s)
The Ospreay	85	0	0	10	100
Willow's Bane Ammo	135	0	20	0	100
Alligator Charge	150	160	0	0	100
Falias Raiding Club	200	0	0	0	100
Hydra's Whisper	100	80	0	0	100
"Molten Wind" v.II Ammo	160	0	200	0	100
Eleos Infantry Dagger	200	0	0	0	100
Shovel	200	0	0	0	100
Water Bucket	80	0	0	0	40
Wrench	75	0	0	0	50
Radio	75	0	0	0	50
Binoculars	75	0	0	0	50
Havoc Charge	75	0	40	0	60
Havoc Charge Detonator	75	0	20	0	60
Buckhorn CCQ-18	40	0	0	0	30
Metal Beam	25	0	0	0	20
Sledge Hammer	200	0	0	0	100
Gas Mask Filter	100	0	0	0	50
Gas Mask	160	0	0	0	100
Sandbag	15	0	0	0	15
Barbed Wire	15	0	0	0	15
Wind Sock	150	0	0	0	60
Radio Backpack	150	0	0	0	75
Listening Kit	150	0	0	0	60
Tripod	100	0	0	0	60

Table 5: $S_{Utility}$ and its costs

There are 5 items in $S_{Medical}$ with 5 being neutral.

	BMats	EMats	HEMats	RMats	time(s)
First Aid Kit	60	0	0	0	35
Bandages	80	0	0	0	40
Blood Plasma	80	0	0	0	40
Soldier Supplies	80	0	0	0	80
Trauma Kit	80	0	0	0	50

Table 6: $S_{Medical}$ and its costs

There is 1 item in $S_{Resources}$ with 1 being neutral.

	BMats	EMats	HEMats	RMats	time(s)
Maintenance Supplies	250	0	0	0	125

Table 7: $S_{Resources}$ and its costs

There are 19 items in $S_{Uniforms}$ with 9 being Warden and 10 being Collie.

	BMats	EMats	HEMats	RMats	time(s)
Caovish Parka	100	0	0	0	90
Gentleman's Peacoat	100	0	0	0	90
Officer's Regalia	100	0	0	0	90
Outrider's Mantle	100	0	0	0	90
Padded Boiler Suit	100	0	0	0	90
Physician's Jacket	100	0	0	0	90
Sapper Gear	100	0	0	0	90
Specialist's Overcoat	100	0	0	0	90
Gunner's Breastplate	150	0	0	0	90
Fabri Rucksack	100	0	0	0	90
Grenadier's Baldric	100	0	0	0	90
Heavy Topcoat	100	0	0	0	90
Legionary's Oilcoat	100	0	0	0	90
Medic Fatigues	100	0	0	0	90
Officialis' Attire	100	0	0	0	90
Recon Camo	100	0	0	0	90
Remex Garb	100	0	0	0	90
Tankman's Coverall	100	0	0	0	90
Velian Flak Vest	200	0	0	0	90

Table 8: $S_{Uniforms}$ and its costs

For Wardens, there are 13 items in $M_{SmallArms}$. For Collies, there are 12 items in $M_{SmallArms}$.

<table>
<tr><th></th><th>BMats</th><th>EMats</th><th>HEMats</th><th>RMats</th><th>time(s)</th></tr>
<tr><td>Clancy-Raca M4</td><td>250</td><td>0</td><td>0</td><td>25</td><td>250</td></tr>
<tr><td>Malone MK.2</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">25</td><td>100</td></tr>
<tr><td>KRN886-127 Gast Machine Gun</td><td>100</td></tr>
<tr><td>Booker Storm Rifle Model 838</td><td rowspan="4">0</td><td rowspan="4">0</td><td rowspan="4">0</td><td rowspan="4">15</td><td>80</td></tr>
<tr><td>Aalto Storm Rifle 24</td><td>80</td></tr>
<tr><td>"Dusk" ce.III</td><td>80</td></tr>
<tr><td>Catara mo.II</td><td>80</td></tr>
<tr><td>No.4 The Pillory Scattergun</td><td rowspan="6">80</td><td rowspan="6">0</td><td rowspan="6">0</td><td rowspan="6">0</td><td>100</td></tr>
<tr><td>"The Pitch Gun" mc.V</td><td>80</td></tr>
<tr><td>PT-815 Smoke Grenade</td><td>75</td></tr>
<tr><td>7.62mm</td><td>50</td></tr>
<tr><td>9mm</td><td>50</td></tr>
<tr><td>Buckshot</td><td>50</td></tr>
<tr><td>No.2B Hawthorne</td><td>70</td><td>0</td><td>0</td><td>0</td><td>60</td></tr>
<tr><td>Cascadier 873</td><td rowspan="2">60</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td>30</td></tr>
<tr><td>Cometa T2-9</td><td>50</td></tr>
<tr><td>A3 Harpa Fragmentation Grenade</td><td rowspan="2">100</td><td rowspan="2">40</td><td rowspan="2">0</td><td rowspan="2">0</td><td>100</td></tr>
<tr><td>Bomastone Grenade</td><td>100</td></tr>
<tr><td>Blakerow 871</td><td rowspan="3">140</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">0</td><td>80</td></tr>
<tr><td>Fuscina pi.I</td><td>80</td></tr>
<tr><td>Green Ash Grenade</td><td>100</td></tr>
<tr><td>Clancy Cinder M3</td><td rowspan="2">130</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td>90</td></tr>
<tr><td>KRF1-750 Dragonfly</td><td>150</td></tr>
<tr><td>The Hangman 757</td><td rowspan="2">125</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td>80</td></tr>
<tr><td>Sampo Auto-Rifle 77</td><td>70</td></tr>
<tr><td>No.1 "The Liar" Submachine Gun</td><td rowspan="5">120</td><td rowspan="5">0</td><td rowspan="5">0</td><td rowspan="5">0</td><td>80</td></tr>
<tr><td>Fiddle Submachine Gun Model 868</td><td>80</td></tr>
<tr><td>"Lionclaw" mc.VIII</td><td>80</td></tr>
<tr><td>Catena rt.IV Auto-Rifle</td><td>90</td></tr>
<tr><td>7.92mm</td><td>60</td></tr>
<tr><td>No.2 Loughcaster</td><td rowspan="4">100</td><td rowspan="4">0</td><td rowspan="4">0</td><td rowspan="4">0</td><td>70</td></tr>
<tr><td>Volta r.I Repeater</td><td>90</td></tr>
<tr><td>Argenti r.II Rifle</td><td>70</td></tr>
<tr><td>12.7</td><td>70</td></tr>
<tr><td>KRR2-790 Omen</td><td>155</td><td>0</td><td>0</td><td>0</td><td>90</td></tr>
<tr><td>KRR3-792</td><td>250</td><td>0</td><td>0</td><td>30</td><td>250</td></tr>
<tr><td>.44</td><td rowspan="2">40</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td>40</td></tr>
<tr><td>8mm</td><td>20</td></tr>
</table>

Table 9: $M_{SmallArms}$ and its costs

For Wardens, there are 18 items in $M_{HeavyArms}$. For Collies, there are 17 items in $M_{HeavyArms}$.

<table>
<tr><th></th><th>BMats</th><th>EMats</th><th>HEMats</th><th>RMats</th><th>time(s)</th></tr>
<tr><td>Willow's Bane Model 845</td><td>165</td><td>0</td><td>0</td><td>30</td><td>50</td></tr>
<tr><td>B2 Varsi Anti-Tank Grenade</td><td>95</td><td>125</td><td>0</td><td>0</td><td>80</td></tr>
<tr><td>20 Neville Anti-Tank Rifle</td><td>150</td><td>0</td><td>0</td><td>0</td><td>37</td></tr>
<tr><td>Carnyx Anti-Tank Rocket Launcher</td><td>125</td><td>0</td><td>0</td><td>15</td><td>75</td></tr>
<tr><td>Mounted Bonesaw MK.3</td><td rowspan="7">100</td><td rowspan="7">0</td><td rowspan="7">0</td><td rowspan="7">5</td><td>250</td></tr>
<tr><td>Malone Ratcatcher MK.1</td><td>125</td></tr>
<tr><td>Cutler Foebreaker</td><td>250</td></tr>
<tr><td>"Typhon" ra.XII</td><td>125</td></tr>
<tr><td>Mounted Fissura gd.I</td><td>125</td></tr>
<tr><td>Lamentum mm.IV</td><td>125</td></tr>
<tr><td>Daucus isg.III</td><td>125</td></tr>
<tr><td>Cutler Launcher 4</td><td>100</td><td>0</td><td>0</td><td>35</td><td>50</td></tr>
<tr><td>Bonesaw MK.3</td><td rowspan="2">100</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">25</td><td>50</td></tr>
<tr><td>Cremari Mortar</td><td>50</td></tr>
<tr><td>BF5 White Ash Flask Grenade</td><td>100</td><td>80</td><td>0</td><td>0</td><td>75</td></tr>
<tr><td>Venom c.II 35</td><td>100</td><td>0</td><td>0</td><td>15</td><td>50</td></tr>
<tr><td>Ignifist 30</td><td>85</td><td>70</td><td>0</td><td>0</td><td>75</td></tr>
<tr><td>KLG901-2 Lunaire F</td><td>50</td><td>0</td><td>0</td><td>15</td><td>100</td></tr>
<tr><td>"Molten Wind" v.II Flame Torch</td><td>185</td><td>0</td><td>0</td><td>25</td><td>50</td></tr>
<tr><td>Bane 45</td><td>150</td><td>0</td><td>0</td><td>40</td><td>125</td></tr>
<tr><td>20mm</td><td>100</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>Mammon 91-b</td><td>100</td><td>20</td><td>0</td><td>0</td><td>80</td></tr>
<tr><td>Anti-Tank Sticky Bomb</td><td>50</td><td>100</td><td>0</td><td>0</td><td>75</td></tr>
<tr><td>AP/RPG</td><td rowspan="2">60</td><td rowspan="2">150</td><td rowspan="2">0</td><td rowspan="2">0</td><td>100</td></tr>
<tr><td>ARC/RPG</td><td>100</td></tr>
<tr><td>Flare Mortar Shell</td><td>60</td><td>15</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>Shrapnel Mortar Shell</td><td>60</td><td>20</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>Mortar Shell</td><td>60</td><td>70</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>RPG</td><td>60</td><td>90</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>Tremola Grenade GPb-1</td><td>75</td><td>100</td><td>0</td><td>0</td><td>80</td></tr>
<tr><td>30mm</td><td>80</td><td>40</td><td>0</td><td>0</td><td>100</td></tr>
</table>

Table 10: $M_{HeavyArms}$ and its costs

For both Wardens and Collies, there are 5 items in $M_{HeavyAmmunition}$.

	BMats	EMats	HEMats	RMats	time(s)
68mm	120	240	0	0	200
250mm "Purity" Shell	120	0	100	0	150
120mm	120	0	10	0	55
150mm	120	0	60	0	65
40mm	160	240	0	0	200

Table 11: $M_{HeavyAmmunition}$ and its costs

For Wardens, there are 14 items in $M_{Utility}$. For Collies, there are 13 items in $M_{Utility}$.

<table>
<tr><th></th><th>BMats</th><th>EMats</th><th>HEMats</th><th>RMats</th><th>time(s)</th></tr>
<tr><td>The Ospreay</td><td>85</td><td>0</td><td>0</td><td>10</td><td>100</td></tr>
<tr><td>Willow's Bane Ammo</td><td>135</td><td>0</td><td>20</td><td>0</td><td>100</td></tr>
<tr><td>Alligator Charge</td><td>150</td><td>160</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>Falias Raiding Club</td><td rowspan="4">200</td><td rowspan="4">0</td><td rowspan="4">0</td><td rowspan="4">0</td><td>100</td></tr>
<tr><td>Eleos Infantry Dagger</td><td>100</td></tr>
<tr><td>Shovel</td><td>100</td></tr>
<tr><td>Sledge Hammer</td><td>100</td></tr>
<tr><td>Hydra's Whisper</td><td>100</td><td>80</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>"Molten Wind" v.II Ammo</td><td>160</td><td>0</td><td>200</td><td>0</td><td>100</td></tr>
<tr><td>Water Bucket</td><td>80</td><td>0</td><td>0</td><td>0</td><td>40</td></tr>
<tr><td>Wrench</td><td rowspan="3">75</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">0</td><td>50</td></tr>
<tr><td>Radio</td><td>50</td></tr>
<tr><td>Binoculars</td><td>50</td></tr>
<tr><td>Havoc Charge</td><td>75</td><td>0</td><td>40</td><td>0</td><td>60</td></tr>
<tr><td>Havoc Charge Detonator</td><td>75</td><td>0</td><td>20</td><td>0</td><td>60</td></tr>
<tr><td>Buckhorn CCQ-18</td><td>40</td><td>0</td><td>0</td><td>0</td><td>30</td></tr>
<tr><td>Metal Beam</td><td>25</td><td>0</td><td>0</td><td>0</td><td>20</td></tr>
<tr><td>Gas Mask Filter</td><td rowspan="2">100</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td>50</td></tr>
<tr><td>Tripod</td><td>60</td></tr>
<tr><td>Gas Mask</td><td>160</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>Sandbag</td><td rowspan="2">15</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td>15</td></tr>
<tr><td>Barbed Wire</td><td>15</td></tr>
<tr><td>Wind Sock</td><td rowspan="3">150</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">0</td><td>60</td></tr>
<tr><td>Radio Backpack</td><td>75</td></tr>
<tr><td>Listening Kit</td><td>60</td></tr>
</table>

Table 12: $M_{Utility}$ and its costs

For both Wardens and Collies, there are 2 items in $M_{Medical}$.

	BMats	EMats	HEMats	RMats	time(s)
First Aid Kit	60	0	0	0	35
Bandages	80	0	0	0	40
Blood Plasma					40
Soldier Supplies					80
Trauma Kit					50

Table 13: $M_{Medical}$ and its costs

For both Wardens and Collies, there is 1 item in $M_{Resources}$.

	BMats	EMats	HEMats	RMats	time(s)
Maintenance Supplies	250	0	0	0	125

Table 14: $M_{Resources}$ and its costs

For both Wardens and Collies, there are 2 items in $M_{Uniforms}$.

	BMats	EMats	HEMats	RMats	time(s)
Caovish Parka	100	0	0	0	90
Gentleman's Peacoat					90
Officer's Regalia					90
Outrider's Mantle					90
Padded Boiler Suit					90
Physician's Jacket					90
Sapper Gear					90
Specialist's Overcoat					90
Fabri Rucksack					90
Grenadier's Baldric					90
Heavy Topcoat					90
Legionary's Oilcoat					90
Medic Fatigues					90
Officialis' Attire					90
Recon Camo					90
Remex Garb					90
Tankman's Coverall					90
Gunner's Breastplate	150	0	0	0	90
Velian Flak Vest	200	0	0	0	90

Table 15: $M_{Uniforms}$ and its costs