Quick planning using "S" curves and cost based durations

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1. Introduction

The miscalculations in the works estimation duration made during initial project stages are not, only a major cause of construction cost overruns as such, but also affect the implementation and therefore the entire balance of income, expenses and financial planning.

This paper proposes a fully automated model for the quick estimation of the time needed to finish a proposed building or civil work, including the total time, the duration of each activity and their sequence, starting from a cost estimate based on work units.

Like existing parametric cost estimating systems, based on averages and statistics, the result is always a rough estimate, but enough to make decisions in the early project stages. Results are obtained with much less effort than required by traditional detailed planning, which should be done, of course, eventually.

In particular, this method allows the analysis on funding needs to implement the project, with a very good approximation from the developer point of view and somewhat less from the construction company.

2. Estimating total duration

The determination of the works expected duration before performing a detailed planning, the first step of this model, can be done in two ways:

- Based on expert judgment
- By applying historical data

These criteria are based on the assumption that a future project will behave in a similar way as similar projects in the past.

In the case of expert's opinion, data deriving from the experience are combined more or less intuitively, choosing the relevant parameters for each case without a formal procedure.

It often happens that the initial expert's estimate, unconditioned, is more accurate than the values subsequently adjusted. The reason is the "fallacy of control". Predictions about events on which we are able to interact, as the task duration, are usually less accurate than those made about what is beyond our control, such as weather predictions.

The second methodology is based on the collection and use of statistical data on similar projects. The work described in (Martin, Burrows & Pegg, 2006) has been developed in United Kingdom. They sought the relationship between the construction duration and the following parameter set, based on information collected by the BCIS Building Cost Information Service in 2700 new buildings, completed between 1998 and 2006:

- Contract amount
- Building use (housing, warehouse, hotel, etc.)

- Sector (public / private, residential / non-residential)
- Procurement and payment system (traditional, design and build, etc.)
- Contractor selection method (one or two stages, negotiated, etc.)
- Client type (local or state, cooperative, private developer, etc.)

The proposed model consists in a relationship between the duration and the logarithm of the construction cost, of the form:

$$Y \text{ (time in weeks)} = A \log X \text{ (cost in 2005 pounds)} + B \qquad (1)$$

The coefficients A and B depend only on the type of use. The construction cost, including all execution costs, except fees and taxes, are adjusted with regional differences and inflation between dates.

Based on this work the BCIS developed a computer program (BCIS, 2009) which takes into account the remaining parameters, although their impact is irrelevant for practical purposes.

The coefficients have been adjusted later with projects in Spain, taken from the Soft collection of actual (Soft, 2006), and are calculated within the Presto program.

The table below shows the values of the coefficients for some uses, as an example.

Table 1. **Relationship between cost and time**

Use	Duration (weeks)
General	22.4 x LOG (€) - 91
Collective housing	33 x LOG (€) - 146
Single family	31 x LOG (€) - 131

A third case may be added to these systems, the need to meet a preset deadline, which can often be decisive. This is the case of projects necessarily having a fixed final date or which are linked to political criteria, such as the next elections date. The term so established also can be used to implement the remainder of this model, with the exception of cases in which any of the former methods show that this term is not at all feasible.

3. Allocation of cost over time

The overall project cost and also the cost of many resources is not distributed evenly throughout the execution. The cost follows a pattern similar to a bell or Gaussian curve, more or less asymmetric and more or less bulky. Expenditure or consumption of these resources, accumulated or integrated from origin, follows also a characteristic curve in the form of the "S" letter. In the case of the Gaussian bell curve, its integral is the so called *logistic curve*.

The first work on this subject was made by Hudson to the late British Department of Health and Social Security (Hudson, 1978). This study, limited to hospitals, provided cubic curves whose parameters are a function solely of the total cost. Different coefficients were obtained for each range of amounts, instead of a unique function.

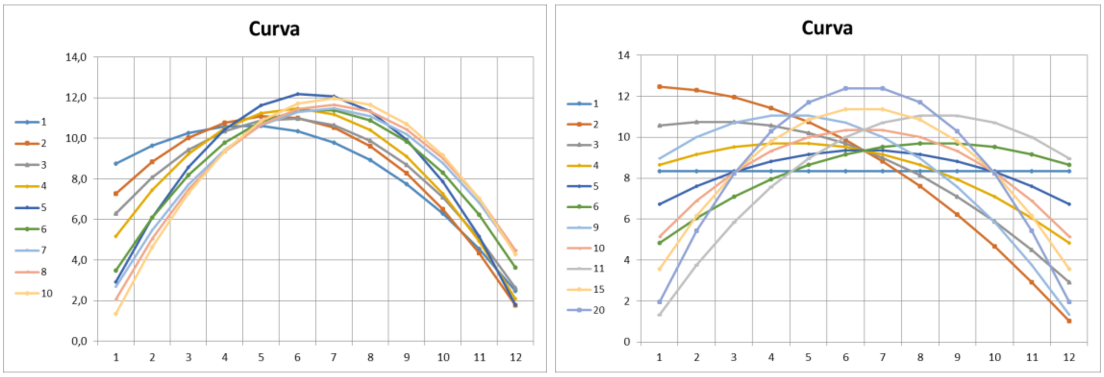
Howes (Howes, R., 1983) performed a comprehensive study on the subject and provided its own parameters for the same curves proposed by Hudson.

Other authors have proposed different expressions and parameters, with the corresponding coefficients and application range:

- Inverted cubic function (Bromilow & Henderson, 1974; 1977).
- Polynomial regression of the 4th degree (Shlomo, 1976; 1982).
- Logit curve (Kenley & Wilson, 1986).
- Trigonometric function (Miskawi, 1989).
- Trilineal or trapezoidal (Wideman, 1994).

Other authors (Banki & Esmaeili, 2009), (Skitmore, 1992) have researched and compared many of these proposals, applying the results to real cases, to detect the predictions accuracy.

Figure 1: Expenses by periods (Hudson and Howes)



As an example, we present the most recent function proposed by Lara and Dinsmore and collected in (Dórea, 2010). The cumulative percentage from origin for each period, using Excel notation, is:

$$\%Origin = 1 - (1 - (n / N)^{\wedge}LOG (I))^{\wedge}s \quad (2)$$

Where:

n = period number

N = number of periods

I, between 0 and 100 (in practice between 30 and 70) indicates the asymmetry of the curve, i.e., the time when maximum spending is reached.

S, between 1.1 and 3.3, (in practice between 1.5 and 2.5) indicates the kurtosis or bulge.

Figure 2: Expenses by periods (Lara and Dinsmore)

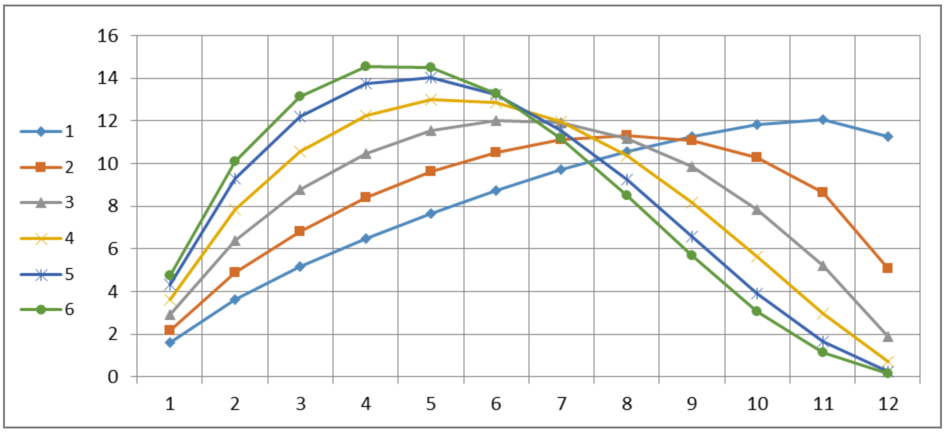


Figure above shows various curves following this pattern, obtained with different parameters, and Table below shows the percentages for the curve number 6.

Table 2. Percentages for Lara and Dinsmore curve number 6

Month	1	2	3	4	5	6	7	8	9	10	11	12
Weight	4,76	10,12	13,15	14,53	14,49	13,27	11,16	8,50	5,67	3,07	1,13	0,14
Acc. weight	4,76	14,88	28,03	42,56	57,05	70,33	81,49	89,99	95,65	98,73	99,86	100,00

Any period may be used, although it is usual to be months; we will use this assumption in the rest of the document.

4. Defining activities and sequencing

Once the time allocation is obtained, using any of former curves or based in a custom method, the activities should be assigned following this spending pattern.

For the application of this model an estimate based in work units must be available, be it more or less definitive. Even in very early stages of projects, current digital systems are able to generate automatic cost estimates accurate enough for this purpose.

It is traditional to arrange the chapters and the work units of estimates following an approximate execution order, so only some adjustments will be usually needed to ensure the work units are located in the right sequence.

The allocation procedure is a simple assignment algorithm, where successive work units are assigned to each certification period until all the planned spending is reached. If an activity has to be split into two periods, certain measures should be applied in order to keep the logic of construction, avoiding excessively small or fragmented fractions work units which by their nature are inseparable.

Figure 3: Activities allocation based on “S” curve (Presto)

		NatC	Code	Description	QtyTgt	Unit	1: Plan 31-Jul-12	2: Plan 31-Aug-12	3: Plan 30-Sep-12	4: Plan 31-Oct-12	5: Plan 30-Nov-12	6: Plan 31-Dec-12	7: Plan 31-Jan-13	8: Plan 28-Feb-13	9: Plan 31-Mar-13	10: Plan 30-Apr-13
1/0	-		***0***	***Housing project***	*1*		***81.819,57***	***94.631,40***	***107.592,89***	***120.252,72***	***132.122,19***	***142.700,30***	***151.509,33***	***158.132,48***	***162.244,74***	***163.639,07***
2/1	+ 1		**E01**	**Preliminaries**	1		**3.981,85**									
3/1	+ 2		**E02**	**Earthwork**	1		**48.877,31**									
4/1	+ 3		**E03**	**Sewage**	1		**10.072,11**									
5/1	- 4		**E04**	**Foundations**	1		**18.888,30**	**46.181,73**								
6/2	+ 4.1		E04CM040	HM-20/P/20/I concrete cleaning	34,59	m3	2.119,68									
7/2	+ 4.2		E04CE020	Wood formwork footings, trenches, beams p	48,68	m2	778,39									
8/2	+ 4.3		E04CA060	HA-25/P/40/IIa concrete, footings	220,88	m3	15.990,23	10.714,16								
9/2	+ 4.4		E04SA020	HA-25 concrete slab reinforced, e = 15 cm	659,35	m2		9.059,47								
10/2	+ 4.5		E04SE020	Limestone 40/80, e = 20 cm	659,35	m2		4.437,43								
11/2	+ 4.6		E04MA010	HA-25/P/20/I in concrete wall 25 cm, 1-sided	88,57	m3		21.970,67								
12/1	- 5		**E05**	**Structures**	1			**48.449,67**	**107.592,89**	**120.252,72**	**132.122,19**	**41.794,27**				
13/2	+ 5.1		E05HFA020	Salb self-supporting beam 20 +5 cm, 60 cm bas	6.277,72	m2		48.449,67	107.592,89	114.778,28						
14/2	+ 5.2		E05AG010	Lintel galvanized steel, 250x4 mm	365,45	m				5.474,44	986,72					
15/2	+ 5.3		E05AW040	Angle of 60 mm	108,00	m					2.066,04					
16/2	5.4		E05HFS400_01	Formation of hollow slab	181,37	m2					8.705,76					
17/2	+ 5.5		E05HLA030	HA-25/P/20 concrete, formwork slabs5 kg/m3	11,66	m3					2.775,08					
18/2	+ 5.6		E05HSA010	HA-25/P/20/I concrete, pillars, metal formwork,	205,16	m3					47.619,69					
19/2	+ 5.7		E05HVA030	Concrete girders with wood framing HA-25/P/2	230,18	m3					69.968,90	1.888,69				
20/2	+ 5.8		E05HVA075	HA-25/P/20/I concrete with flat bands	107,85	m3						39.905,58				
21/1	+ 6		**E07**	**Walls and divisions**	1							**100.906,03**	**151.509,33**	**77.457,39**		
22/1	+ 7		**E08**	**Cladding and suspended ceilings**	1									**80.675,09**	**89.886,69**	
23/1	+ 8		**E09**	**Covers**	1										**40.090,04**	
24/1	+ 9		**E10**	**Insulation and waterproofing**	1										**32.268,01**	**59.251,19**

Total duration obtained from (Martin, Burrows & Pegg, 2006), corresponding to housing development with an estimated contract value of 3,083,000 €. Spending pattern follows a Gaussian bell curve.

The estimate work units represent billable work components to be satisfied by the client, and therefore are suitable for analyzing both the cost for the developer as the income for the construction company.

However, the work units do not always match the activities used in programming the schedule. Therefore, from the construction company point of view additional tuning is needed, defining explicitly site overhead and its temporary breakdown, including mobilization and demobilization, and assigning proportional costs and home overhead, as defined by the corporate policy. Hereafter elements used in planning will be referred as “activities”, are they or not work units.

Naturally, depending on the considered viewpoint, contract prices or estimated costs shall be used, obtained from each other, if desired, using a global markup.

Revenues and costs are assumed to be incurred at the end of each period, although for cash flow financial simulations they must be assigned to the expected payment terms, to situate them accurately in time.

If price breakdowns are available, the same system calculates the consumption of resources over time, in relation to the work units where they are needed. If these resources are allocated to their respective payment terms, sometimes very far from the end of the period, a very accurate cash flow planning from the construction company point of view may be prepared, allowing for a full financial analysis of the works.

5. Activities duration

The model assumes, in principle, the existence of a proportionality relationship between the cost of each activity, the total cost of the work and their respective durations.

$$\textit{Activity duration} = \textit{Duration of the work} \times \textit{Activity cost} / \textit{Cost of the work} \qquad (3)$$

This assumption is very close to reality if instead of the total cost, the cost of machinery resources and labor is used, total and by each activity, as these figures affect the consumption of time, removing the cost of materials. In any case, this paper will use the generic term "cost".

The direct application of this direct proportionality however generates an unrealistic schedule, all activities immediately one after the other, as if there depending on start-finish links, also providing a too short duration for all of them. Should we know the number of simultaneous activities, a better expression would be,

Activity duration = Duration of the work x Activity cost
x Number of simultaneous activities / Cost of the work *(4)*

To obtain an estimation for this figure, may be observed that the number of activities executed simultaneously on the site, is related to the total number of activities. In a work with a single activity only one activity may be performed at the same time. In a work with thousands of activities there are dozens of them running simultaneously. This observation suggests a potential relationship of the type:

Number of simultaneous activities = SQRT (Number of activities) *(5)*

This criterion can be improved with two successive corrections.

First, the activities of greater economic impact in the site usually receive more attention and more resources, and the opposite occurs with small activities. This is not reflected in the above criteria, with which all alike are compressed.

To take this into account, the total estimated number of activities used to calculate the duration of one of them should be calculated as if all of them had the same cost, and will be therefore different for each activity:

Number of simultaneous activities for activity A =
SQRT (Cost of the work / Activity A cost) *(6)*

Replacing in the above expression and simplifying returns:

Activity A duration = SQRT (Activity A cost / Cost of the work)
x Duration of the work *(7)*

This method also frees the duration of each activity from the total number of activities, so its calculation is not needed.

It is also desirable to introduce some adjustment factor for durations that can be modified freely by the scheduler, so obtaining a better fit to actual observations.

Since the square root of a value equals to raise the value to the power 0.5, let´s substitute this for a variable exponent V:

Number of simultaneous activities for activity A =
(Cost of the work / Activity A cost) ^ V *(8)*

Replacing and simplifying gives the final expression:

Activity A duration = (Activity A cost / Cost of the work) ^ (1 - V)
x Duration of the work *(9)*

V, which may vary between 0 and 1, is actually a simultaneity coefficient.

- The coefficient V “zero” indicates no concurrent activities. Activities are executed one after the other and its duration, the shortest possible, it is strictly proportional to the work duration.
- The coefficient V “one” indicates that simultaneity is absolute. All activities start and finish at the same time and have the same duration as the work.

V values between these extremes, close to 0.50, allow obtaining practical durations.

For example, the calculated duration for an activity whose cost is 4% of the cost of a work which will take 52 weeks is:

$$\textit{Activity duration} = (4 / 100) \wedge (1 - 0.5) \times 52 = 10.40 \textit{ weeks} \approx 47 \textit{ working days} \quad (10)$$

If cost elements are groups of activities, as traditional trade divisions, the overlap is clearly higher, with coefficient V closer to 0.60; if cost elements are at the work units level, V values should be closer to 0.40.

Number of crews

These durations represent a reasonable total time. If the resources breakdown for the activities is available, a different duration may be calculated, multiplying the quantity of the main resource by the total work unit quantity. This duration represents hours or days of work for a single crew or equipment piece. Therefore, the ratio between durations obtained from both methods provides again a quick estimate of the number of crews or equipment required to perform the task within a period consistent with the total duration of the work.

$$\textit{Number of crews} = \textit{Duration based on breakdown} / \textit{Cost based duration} \quad (11)$$

Figure 4: Automatic activities duration (Presto)

		Code	NatC	Description	QtyTgt	AmntTgt	Unit	Equip...	DurTime	DurCostRes	DurCost
1/0	**-**	**0**		**Housing project**	1	**2.465.650,18**		**1**	**0**	**428**	**428**
2/1	**+ 1**	**E01**		**Preliminaries**	1	**3.981,85**		**1**	**0**	**8**	**5**
3/1	**+ 2**	**E02**		**Earthwork**	1	**48.877,31**		*2*	**0**	**50**	**28**
4/1	**+ 3**	**E03**		**Sewage**	1	**10.072,11**		*3*	**0**	**9**	**9**
5/1	**- 4**	**E04**		**Foundations**	1	**65.070,03**		**1**	**0**	**29**	**34**
6/2	*4.1*	*E04CM040*		*HM-20/P/20/I concrete cleaning, manually Poured*	*34,59*	*2.119,68*	*m3*	*1*	*3*	*2*	*3*
7/2	*4.2*	*E04CE020*		*Wood formwork footings, trenches, beams and pile c*	*48,68*	*778,39*	*m2*	*1*	*3*	*2*	*2*
8/2	*4.3*	*E04CA060*		*HA-25/P/40/IIa concrete, footings, Poured by crane*	*220,88*	*26.704,39*	*m3*	*1*	*6*	*13*	*18*
9/2	*4.4*	*E04SA020*		*HA-25 concrete slab reinforced with wire mesh, e =*	*659,35*	*9.059,47*	*m2*	*1*	*0*	*6*	*9*
10/2	*4.5*	*E04SE020*		*Limestone pitching 40/80, e = 20 cm*	*659,35*	*4.437,43*	*m2*	*4*	*21*	*6*	*5*
11/2	*4.6*	*E04MA010*		*HA-25/P/20/I in concrete wall 25 cm, 1-sided, hand*	*88,57*	*21.970,67*	*m3*	*1*	*0*	*17*	*16*
12/1	**- 5**	**E05**		**Structures**	1	**450.211,74**		**1**	**0**	**128**	**130**
13/2	*5.1*	*E05HFA020*		*Forged from self-supporting beam 20 +5 cm, 60 cm i*	*6.277,72*	*270.820,84*	*m2*	*3*	*273*	*83*	*91*
14/2	*5.2*	*E05AG010*		*Lintel of hollow galvanized, 250x4 mm*	*365,45*	*6.461,16*	*m*	*2*	*14*	*8*	*7*
15/2	*5.3*	*E05AW040*		*Angle of 60 mm at auction*	*108,00*	*2.066,04*	*m*	*2*	*7*	*3*	*3*
16/2	*5.4*	*E05HFS400_01*		*Formation of hollow forged hoop attached Edge*	*181,37*	*8.705,76*	*m2*	*1*	*0*	*0*	*9*
17/2	*5.5*	*E05HLA030*		*HA-25/P/20 concrete, formwork slabs of wood Inclin*	*11,66*	*2.775,08*	*m3*	*1*	*1*	*4*	*4*
18/2	*5.6*	*E05HSA010*		*HA-25/P/20/I concrete, pillars, metal formwork, 80 k*	*205,16*	*47.619,69*	*m3*	*1*	*7*	*32*	*27*
19/2	*5.7*	*E05HVA030*		*Concrete girders with wood framing hang HA-25/P/*	*230,18*	*71.857,59*	*m3*	*1*	*5*	*37*	*36*
20/2	*5.8*	*E05HVA075*		*HA-25/P/20/I concrete with flat bands, With woode*	*107,85*	*39.905,58*	*m3*	*1*	*2*	*31*	*24*

DurTime calculation is based on labor rates. DurCostRes (resource cost based durations) and DurCost (total cost based durations) follow the method described in the text, with a simultaneity coefficient V = 0.3.

The durations obtained can be used to get a fast planning, as described above, and also can act as quick references for the activities of a traditional planning, based on precedencies, quickly creating the Gantt chart before a detailed analysis is performed.

6. Case studies

Commercial center with office space and parking

The planning of the shopping center is broken down and valued at the division level, so the simultaneity coefficient to be used must be in the upper range. We adopt the value V = 0.6.

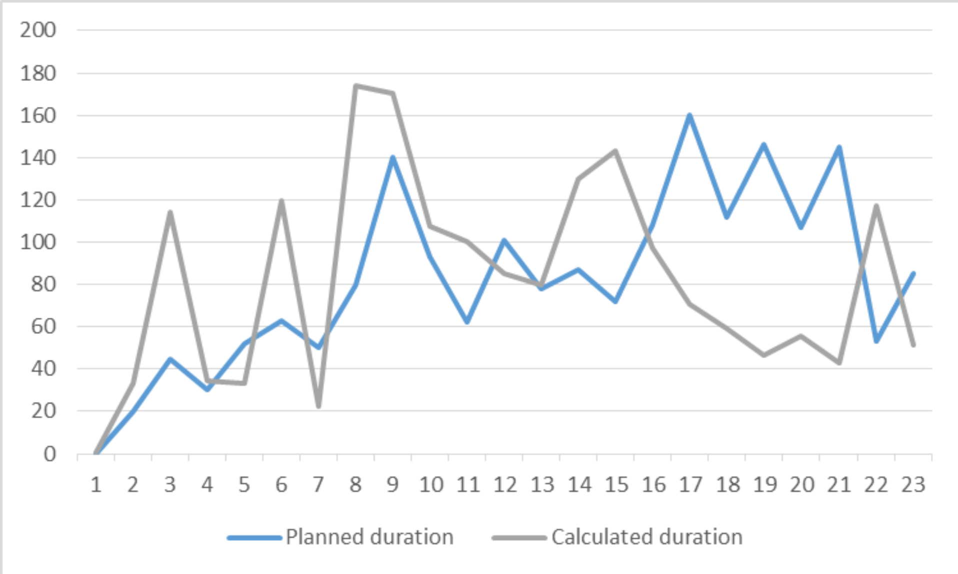
Table 3: Planned vs. calculated durations

Division	Cost	Resources	Planned duration	Calculated duration	Difference	Change
	€	%	d	d	d	%
Preliminaries	10,640	87	20	29	9	44
Earth work	300,843	81	45	106	61	136
Water disposal	27,470	37	30	30	0	0
Waterproofing	23,768	39	52	29	-23	-45
Foundation	810,562	34	63	112	49	77
Grounding	10,192	31	50	19	-31	-63
Concrete structure	2,026,690	37	80	167	87	109
Facade	1,422,344	50	140	163	23	17
Finishes	318,173	66	93	100	7	8
False ceilings	298,917	58	62	93	31	50
Roof	400,127	28	101	78	-23	-23
Thermal & Moisture Prot.	277,577	34	78	73	-5	-7
Pavements	880,285	39	87	122	35	40
Internal divisions	700,194	64	72	136	64	89
Electrical	399,788	40	108	90	-18	-17
Plumbing	202,562	34	160	64	-96	-60
Air conditioning	225,979	19	112	53	-59	-53
Ventilating	96,539	23	146	41	-105	-72
Lifting equipment	303,080	12	107	50	-57	-54
Fire protection	104,806	17	145	37	-108	-74
Paintings	477,654	55	53	110	57	107
Special facilities	107,568	27	85	45	-40	-47
Total	9,425,758	43	327		-142	164
Mean					-6	7
Standard deviation					56	65

Note: The resources cost is estimated from the total cost using an average percentage, specific for every division, taken from Soft (1996-2000).

To evaluate the accuracy of the resulting durations the chosen variables have been the difference in days and the percentage of change. The table shows the sum, the mean and standard deviation for both series of values. Even standard deviation is high, the average of both series is fairly low, suggesting an interesting path for further research.

Figure 5: Planned vs. calculated durations



It should be noted that the significant differences observed in the final divisions, which correspond to mechanical and electrical facilities, are due to these chapters embrace activities widely separated in time, with idle time in between.

Residential building

The project estimate is detailed at the work unit level, so the simultaneity coefficient should be taken at the lower end of the range, V = 0.40, but the table shows also results for V = 0.30, V = 0.50 and the direct proportional duration, with V = 0.00.

The total duration results of applying the BCIS formula to the total cost, with the coefficients corresponding to the housing type. Planned durations have been calculated based on resources efficiency, as published in GTP (2012). The total number of days is adjusted with the number of crews appropriate to each stage of construction, as listed in the following table.

Table 4: Crews used in the planning

Trade	No. of crews
Foundation, structure	2
Brickwork, painting	3
Finishes, facilities	2
Other activities	1

Table 5: Calculated durations for different V values

Work unit	Resource cost	Planned duration	V	Dif.	V	Dif.	V	Dif.	V	Dif.
	€		0.00		0.30		0.40		0.50	
Refinement of trenches	4,921	19	2	-17	9	-10	15	-4	27	8
Excavation	4,354	16	1	-15	8	-8	14	-2	25	9

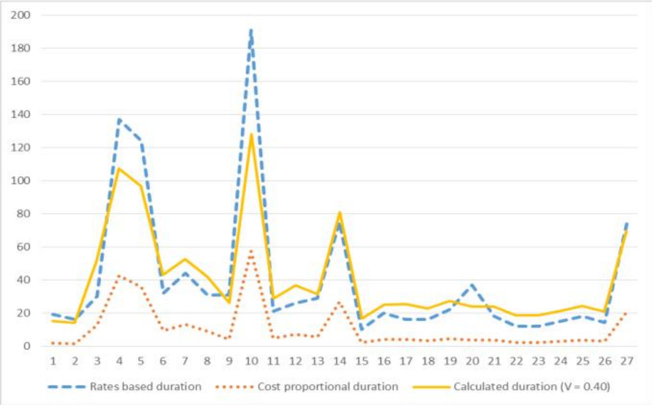
Work unit	Resource cost	Planned duration	V	Dif.	V	Dif.	V	Dif.	V	Dif.
	€		0.00		0.30		0.40		0.50	
Transport to landfill	38,013	30	13	-17	37	7	52	22	74	44
Forged joist	127,127	137	43	-94	85	-52	107	-30	135	-2
Brickwork, 1'	106,786	124	36	-88	75	-49	97	-27	124	0
Id. 1/2'	27,717	32	9	-23	29	-3	43	11	63	31
Id. single int. partition	38,539	44	13	-31	37	-7	52	8	74	30
Id. double int. partition	26,806	31	9	-22	29	-2	42	11	62	31
Final cleaning	12,199	31	4	-27	17	-14	26	-5	42	11
Plaster finish	171,322	191	57	-134	105	-86	128	-63	157	-34
Inverted flat roof	14,109	21	5	-16	18	-3	29	8	45	24
Sound insulation	21,373	26	7	-19	24	-2	37	11	55	29
Tile Flooring	16,399	29	5	-24	20	-9	31	2	49	20
Oak flooring	79,356	75	27	-48	61	-14	81	6	107	32
Continuous pavement	5,707	10	2	-8	10	0	17	7	29	19
Ceramic tiles	11,328	20	4	-16	16	-4	25	5	40	20
Natural ceramic tiles	11,378	16	4	-12	16	0	25	9	40	24
Doors	9,485	16	3	-13	14	-2	23	7	37	21
Front cabinets	12,808	22	4	-18	17	-5	27	5	43	21
Steel fence	10,286	37	3	-34	15	-22	24	-13	38	1
Base plug	10,269	18	3	-15	15	-3	24	6	38	20
10 A circuit	6,788	12	2	-10	11	-1	18	6	31	19
15 A circuit	6,701	12	2	-10	11	-1	18	6	31	19
20 A circuit	8,525	15	3	-12	13	-2	21	6	35	20
25 A circuit	10,656	18	4	-14	15	-3	24	6	39	21
Radiator element	8,262	14	3	-11	13	-1	21	7	34	20
Paint	61,541	74	21	-53	51	-23	69	-5	94	20
Total	1,276,293	428		-801		-321		2		479
Mean				-30		-12		0		18
Standard deviation				30		20		17		15

All durations are in days

The resulting duration for V = 0.40 shows a well-compensated estimation, with also a low standard deviation. The comparison between the different V values suggests that when the proper value for the typology is found, the estimation could be very accurate, with growing differences as the coefficient moves away from this value.

The value obtained with V = 0.00 represents the simple hypothesis that duration could be directly proportional to cost. The amount of the differences with the calculated duration proposed in this paper is a good measure of the potential of this procedure.

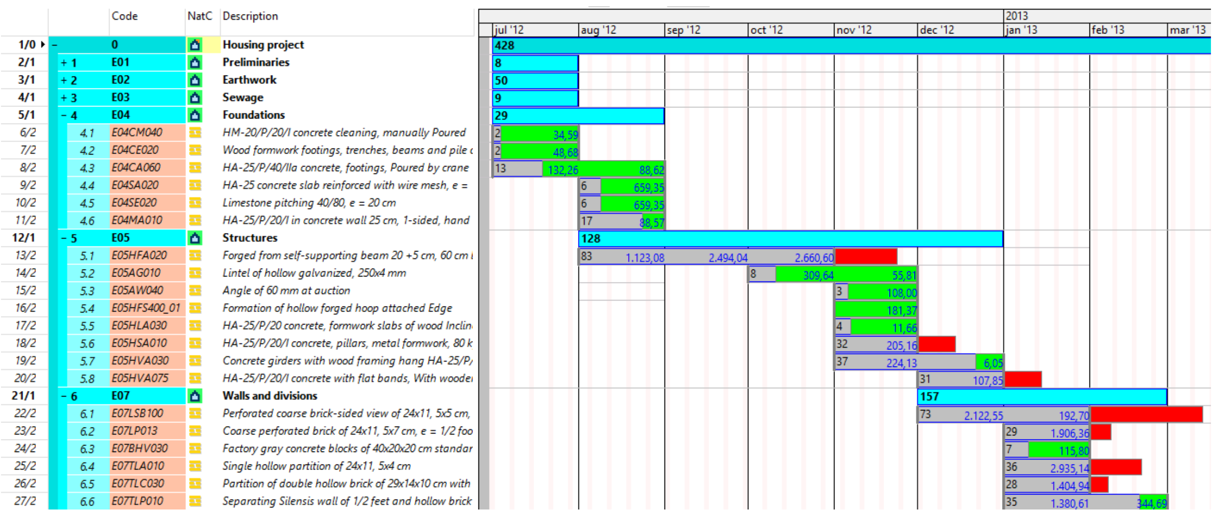
Figure 6: Planned, proportional and calculated durations



7. Conclusions

The model described in this paper allows defining the allocation of costs along the time, at an early project stage, before making a more precise traditional planning.

Figure 7: Final results (Presto)



Note: The resource cost based duration, at the left end of the bar, is shown in grey color. Red bars show activities where resource cost based duration is longer than the period corresponding to the "S" curve. The blue figure is the quantity allocated to the financial period.

Starting from an estimate detailed at the work unit level, or even at division level, the procedure is completely automatic, with the following decision points:

- Deciding the BCIS coefficients for the total duration
- Checking the right sequential order in the estimate
- Selecting the S" curve more suitable for the project
- Deciding the simultaneity coefficient.

If breakdowns of unit prices in labor resources and machinery are available, as usual in Spanish construction price databases, greater accuracy will be obtained, and also an estimation of the number of crews needed during the execution.

As future tasks, a comprehensive set of projects must be collected and analyzed in order to refine and further validate the method, finding V coefficients for different typologies or new parameters, if needed, providing a quick, reliable time estimating procedure for professionals and construction companies .

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