Risks and Disruption in Engineering & Construction

Text submitted to "The Association of Cost Engineers – A Cost E" for the one-day seminar entitled "Cost and Programme Management for International Projects" to be held at the Institution of Civil Engineers, Great George Street, Westminster, London on Thursday 10th April 2003.

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A. General

The present paper refers to a previous text, in Italian, that has been printed on the quarterly review of the AICE[1], ***Ingegneria Economica***, no 52/1995, as well as to the paper submitted by the Author to the yearly forum of the AICE in 1997. Both have been updated and integrated.

The purpose of the paper is to analyse the different causes that can bring a project to disruption. Reality, throughout the world, shows a lot of uncompleted projects, together with other projects completed with severe delays or major cost overrun. In some cases, the project can be completed, in other cases it will remain forever like an uncompleted monument.

Furthermore, from those cases, always follows litigation or arbitration procedures, since each party is trying to recover its costs and to leave the blame with the others. In case the project is not properly controlled, by means of proper quantitative methods, the real causes of the disruption are difficult and sometimes impossible to be understood.

B. Causes of disruption

The possible causes of disruption can be classified and analysed with the same pattern normally used to classify the risk. As a matter of fact, we have disruption when a risk becomes reality.

At the bottom line, the causes of disruption can be summarised as follows:

- **external causes**, namely causes not directly pertaining to the project itself, such as the so called *force majeure.* This normally includes
  - the acts of Government (new laws, new regulations, new programmes) that in general give to the Contractor some rights for compensation,
  - the so called acts of God (earthquakes, hurricanes, storms, etc.), that can normally be transformed from unknown risks to known costs by means of an insurance contract,
  - social and political events, such as declared on undeclared wars, rebellions and other upheavals that can be sometimes transformed to costs, at least in part, by means of private insurance contract or governmental export insurances;

[1] The AICE is the Italian Society for Total Cost Management, member of the ICEC.

- **internal causes**, that are strictly belonging to the project, that can be classified into
  - technical causes,
  - economic causes,
  - financial causes.

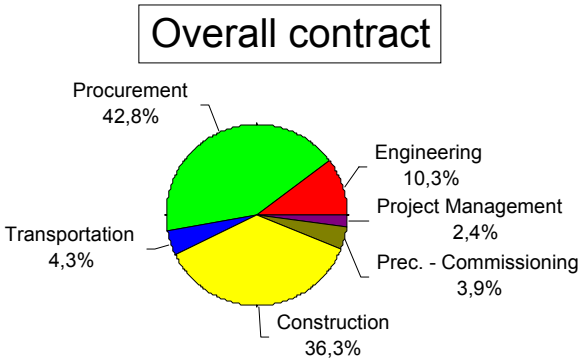
C. The case of the petrochemical plant

C.1. The project referred to

The project referred to for our studies and simulations has been a petrochemical project in an extra-european country. The country was a mixed-economy country with a medium development level, the project was assigned on a turn-key contract to a German General Contractor. The overall contract amount was 1 200 000 000 ECU[2] divided as follows:

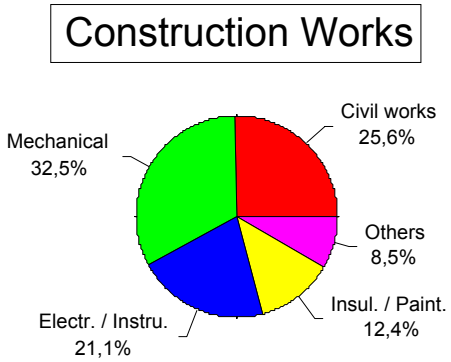
AREA	AMOUNT ECU	AMOUNT ECU	% TOT.	% CONSTR.
Engineering	124 000 000		10.29%	
Procurement	516 000 000		42.82%	
Transports	52 000 000		4.32%	
Construction	437 000 000	437 000 000	36.27%	100.00%
Civil works		112 000 000		25.63%
Mechanical		142 000 000		32.49%
Electr. / Instrum.		92 000 000		21.05%
Insul. / Painting		54 000 000		12.36%
Others		37 000 000		8.47%
Pre-commissioning & Commissioning	47 000 000		3.90%	
Project Management	29 000 000		2.41%	
	1 205 000 000		100.00%	

The amounts shown include for the overhead and profit of the General Contractor. The simulation has been performed with reference to the contract for the Mechanical Works, whose amount was 130 000 000 ECU (so, the General Contractor kept a margin of 12 000 000 ECU about).



[2] The contract referred to was stipulated in the Nineties, so the contract amount is still in ECU (European Currency Unit) instead of being in Euros.

Since our study has been done on behalf of the Mechanical Subcontractor, we shall refer to the contract amount of 130 000 000 ECU, corresponding to the amount stipulated for the subcontract.



C.2. Project control

A prerequisite for keeping a project under control, as well as to cope with the emergencies and to avoid disruption is a sound system of planning, scheduling, progress controlling, cost controlling, cash flow controlling, id est to say, a sound system of planning and project control.

Also simulation to foresee possibilities of disruption and then keep the relevant risk under control is only possible if such a system is in operation.

In detail, when we are trying to define the **progress rate** of a given project, we should know that this word indicates different concepts and different ways of measurement.

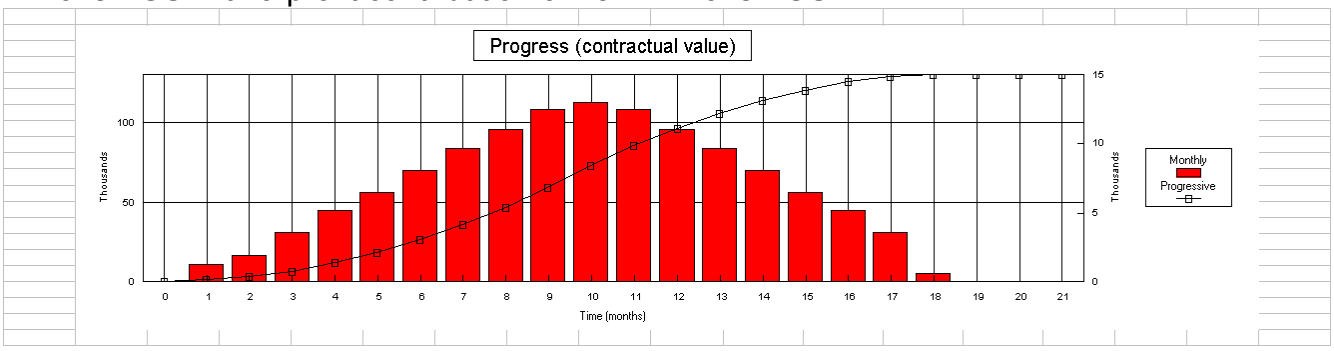
- **Quantitative progress** or **progress** properly so said is a technical measurement based on the ratio of the standard work-load corresponding to the works actually performed to the standard work-load corresponding to the whole of the works[3]. To be able to calculate a sound quantitative progress we need
  - a reliable and detailed bill of quantities,
  - a statistic data base of standard productiveness for every working class or sub-class,
  - a statistic composition criterion for items in progress, as well as
  - a proper criterion to manage small contingencies due to work variation.
- **Economic progress**, that can be better defined, case by case, as
  - **contract progress** (contractual statement of works performed / contract amount),
  - **earned value progress** (earned value of works performed/contract amount or earned value of cost/budget cost)
  - **cost progress** (cost to date / budget cost)
- **Financial progress** (cash received/contract amount).

[3] Standard workload is normally measured in standard man-hours or normal man-hours and can be calculated from the database of standard productiveness. However, in case standard productiveness data are not available, the same result could be obtained by comparison of the estimated man-hours corresponding to the works performed to the estimated man-hours corresponding to the whole of the works or by means of other approximate methods.

By using the said planning and project control system, we have been able to simulate different situations that could bring to disruption, without waiting things to happen.

C.3. Budgeted planning

The starting point of the simulation was to consider the planning data as per budget. Out of a contract amount of 130 millions ECU, the costs budgeted were 101.8 millions ECU with a profit contribution of 28.2 millions ECU.



It is worthy to note that we have considered the contract value of the progress, namely the value of the monthly statement. This has been possible because, according to our contract, the amount to be paid monthly as per contract was calculated as a percentage of the contract amount as per quantitative progress report.

The main data budgeted were the following:

	Millions ECU	Ratio
Contract amount	130000000	100.00%
Direct costs	78000000	60.00%
Project overhead costs	23800000	18.31%
Total costs (direct + overhead)	101800000	78.31%
Profit contribution	28200000	21.69%
Contract amount to total project costs (k)		1.277
Overhead to total costs		23.38%
Financial requirements, maximum	14575000	11.21%
Financial requirements, average	809000	0.62%

It is worthy to note the following:

- the ratio of the contract amount to total project costs is k=1.277, id est to say that profit contribution shall be 21.7% of the contract amount, to cope with the profit itself and overhead costs of the company as a whole; this ratio could be compared with the ratio stipulated in the Italian law 741/81 that allows, for public works, a profit ratio equal to 10% of the contract amount and overhead costs up to 15% of the contract amount less profit, namely 15% x 90% = 13.5% of the contract amount, without dividing project overhead from general overhead[4];

[4] It is worthy to note that, in current practice of arbitration procedures, 2/3 of this amount is considered as project overhead cost.

- even in case everything goes according to what we have planned the project has a financial requirement of 11.2% of the contract amount; the idea of a project that completely finances itself is, in general, a pure illusion.

	This project	Standard project as per law 741/81
Contract amount	130000000	130000000
Profit	28200000	13000000
General overhead		5850000
Project Overhead	23800000	11700000
Direct costs	78000000	99450000
k	1.277	1.170

It is easy to understand, from the above table, that the standard project as per law 741/81 is based on optimistic assumptions relevant to overhead costs and profit contribution as a whole, as well as to project overhead costs. As a matter of fact, the law was never used to keep under control the profit that is market driven, but to keep under control the additional costs due to cost escalation or claims, whose amount had to be calculated as per terms of said law.

C.4. Simulation of different causes that could lead to disruption

a) Simulation procedure

The study was based on a series of preceding experiences of the company in the previous decade, relevant to disrupted contracts in several countries. In those cases, the company had to suffer sensible losses so that its own survival was at risk.

From that was originated the idea of study, when still in phase of preventive, varied possibility of problems that could have been verified during construction, for understanding their consequences. By this way, quantitative methods can take the place of intuition.

The simulation was extended to varied hypothesis of possible problems. The simulations performed have been 120 about, out of which we are presenting now only few any cases.

b) Disruption

Let us now analyse the various forms of disruption of a construction contract, taking into consideration that, in reality, they are generally combined each other in a confused manner.

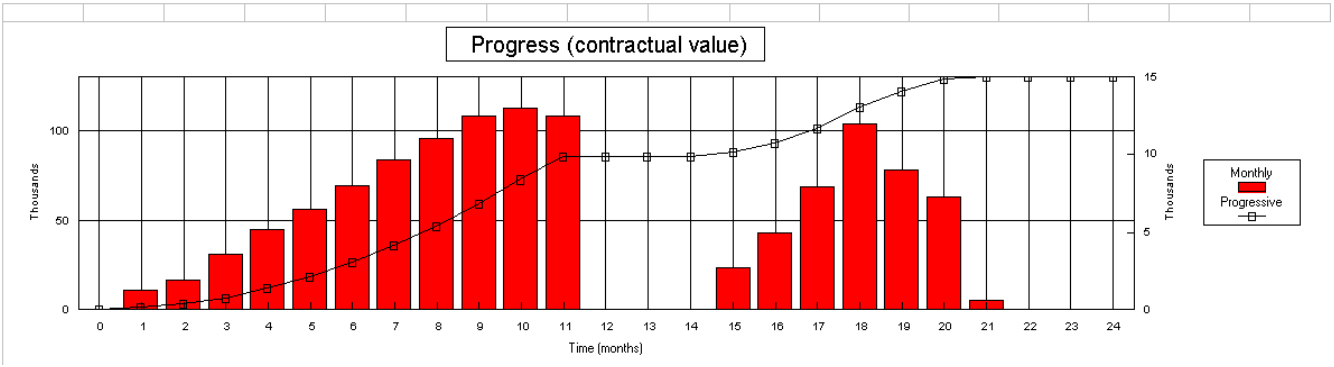
Several factors can create an increase of the costs or a delay, but disruption does not follow necessarily.

We define **disruption** a situation where one of the parameters, generally the financial requirement, arrives at to the limit of its field of variability and becomes then a conditioning factor for the project to go on. According to the cases, disruption can be reversible, when it shall be possible complete the plan somehow within the same framework, or irreversible.

c) Suspension of the works

A typical case of technically driven disruption is "a suspension of the works caused by action of an external body (government, judicial authority) or by external factors beyond any possibility of control". According to the contract under consideration, interruptions of the works of this kind and whose duration was less than three

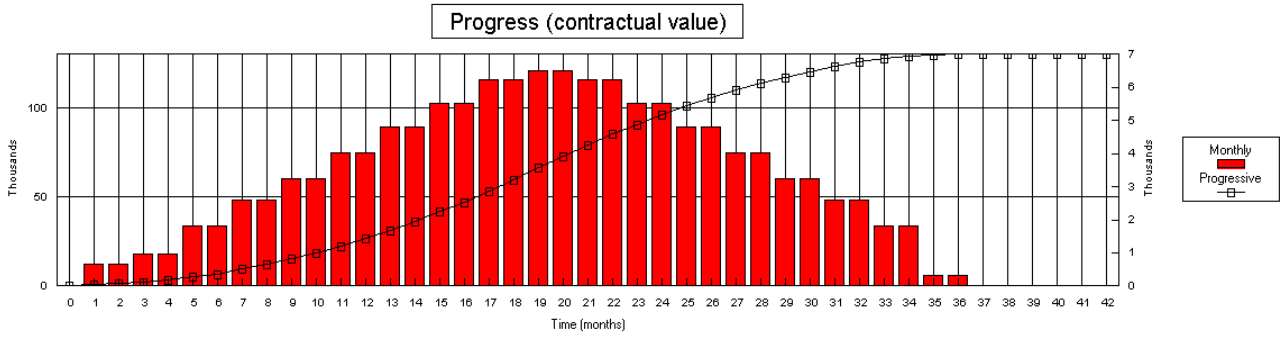
months had the only effect to delay the contract time for completion without giving the possibility for economic claims neither from a part nor the other.
Let us have a look now to see what could happen in case the works are suspended, for external reasons, for three-month time.



The table shows the simulation of a temporary suspension with three-month duration, whose effects can be coped with so that the final delay is only three months.
This fact is not cause of disruption, but only of an increase of the costs, because of the indirect costs of the suspension time as well of the costs of mobilization and demobilization.
The project data shall change as follows:

	Millions ECU	**Ratio**
Contract amount	130000000	100.00%
Direct costs	78000000	60.00%
Project overhead costs	29700000	22.85%
Total costs (direct + overhead)	107700000	82.85%
Profit contribution	22300000	17.15%
Contract amount to total project costs (k)		1.207
Overhead to total costs		27.58%
Financial requirements, maximum	15398000	11.84%
Financial requirements, average	2252000	1.73%

please note that while profit contribution decreases, there is an increase of financial requirements.
d) Slow performance of the works
Let us consider now the simulation of a slow performance course slow down of the works. In detail, we assume that, in each month, the actual progress is 50% of the planned. This hypothesis is not far from a lot of real cases.



Also in this case we can note that profit contribution will decrease, the average financial requirement increases while the maximum financial requirement is reduced.

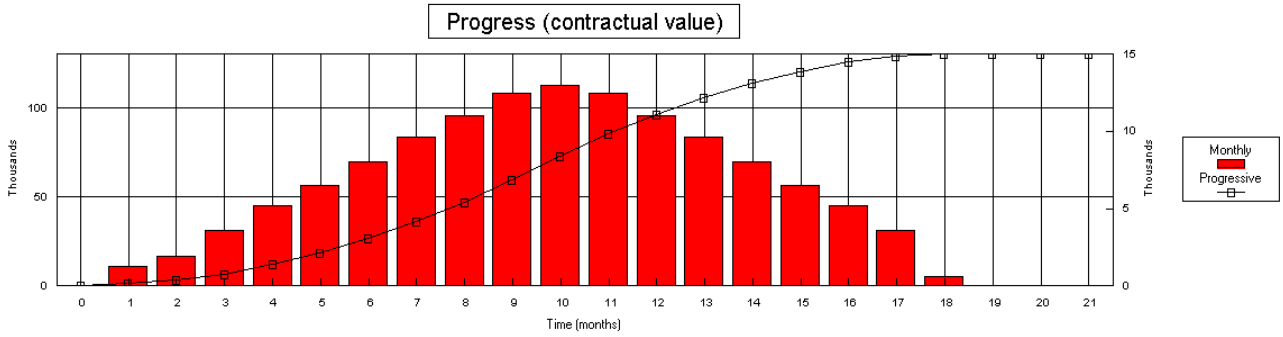
	Millions ECU	**Ratio**
Contract amount	130000000	100.00%
Direct costs	78000000	60.00%
Project overhead costs	38200000	29.38%
Total costs (direct + overhead)	116200000	89.38%
Profit contribution	13800000	10.62%
Contract amount to total project costs (k)		1.119
Overhead to total costs		32.87%
Financial requirements, maximum	9253000	7.12%
Financial requirements, average	4891000	3.76%

e) Disruption due to economic reasons

The economic causes of disruption are basically an increase of the direct or indirect costs. In the considered case an increase of the costs could be due to:

- increase of the quantities to install because of variations or errors of the planning; such costs in general can originate a claim, even in case of lump sum contracts;
- increase of the unit costs, due to increase of the manpower rates; such extra-costs are in general included in the contractor's risk;
- scarce efficiency, that is increase of the number of hours of installation needed to perform the works and consequent increase of indirect hours for the need of more supervision;
- lack of proper organisation that is increase of the number of indirect hours to parity of direct hours.

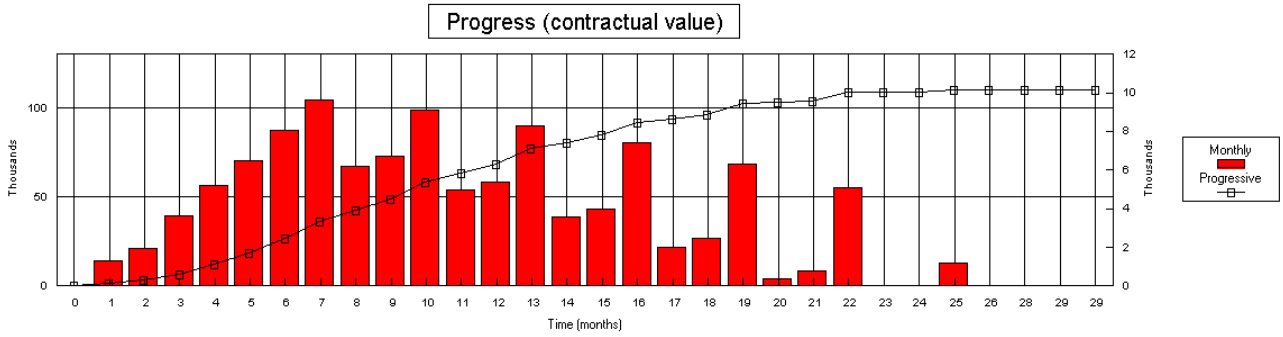
The first simulation shows an increase of the indirect costs of the 50%. This is a severe hypothesis, but not at all distant from many real situations.



The works are still completed in time, while the economic result is completely distorted; the value of financial requirements is almost doubles.

	Millions ECU	**Ratio**
Contract amount	130000000	100.00%
Direct costs	78000000	60.00%
Project overhead costs	32200000	24.77%
Total costs (direct + overhead)	123200000	94.77%
Profit contribution	6800000	5.23%
Contract amount to total project costs (k)		1.055
Overhead to total costs		26.14%
Financial requirements, maximum	27955000	21.50%
Financial requirements, average	13617000	10.47%

The further simulation shows the case of a general economic disruption. In the same above hypothesis, we consider the further case that contractor be not able to increase its financial commitment beyond16 million ECU.
We see that, beginning from the eighth month, the limits of available finance begin to condition the progress, whose curve shows characteristic pulsating shape of disrupted projects. In reality, it makes sense to say that "some works are performed when the payments arrive."
The situation is worsening. Starting from the 22.nd month, when the works are already in heavy, the situation becomes unbearable and the works have to be suspended. After an attempt to resume, suspension becomes definitive. The contractor is not able to cope with more costs and financial requirement and then it's not able to complete the contract. Probably the Owner too shall have to face global problems of stability of its own organisation.



	Millions ECU	Ratio
Works performed	110300000	
Direct costs	66180000	60.00%
Project overhead costs	39800000	36.08%
Total costs (direct + overhead)	117010000	106.08%
Profit contribution		
Contract amount to total project costs (k)		0.951
Overhead to total costs		34.04%
Financial requirements, maximum	20635000	15.87%
Financial requirements, average	18127000	13.94%

f) Disruption due to financial reasons

Between the financial causes of disruption, the most common are:

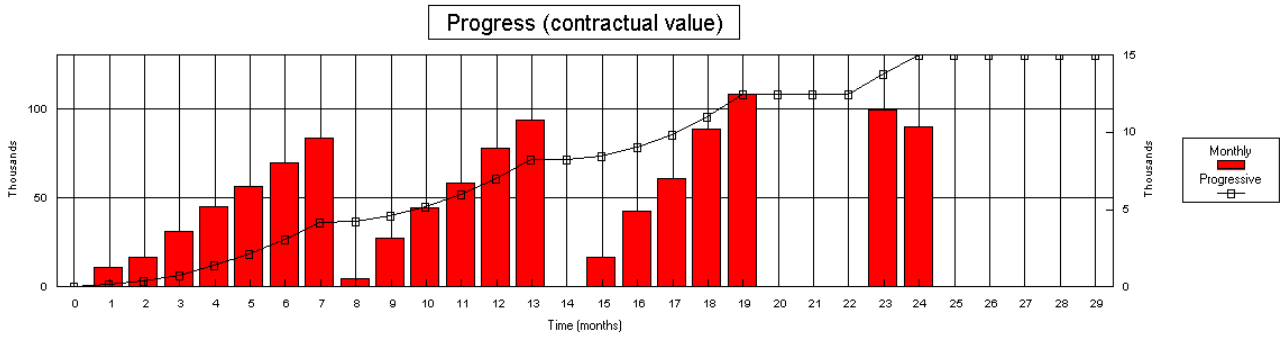
- the prolongation of the actual payment time or, in general delays in the payments,
- the deterioration of the currency mix contractually stipulated or,
- the deterioration of the financial capacity of the contractor, due to external causes.

The simulation shows the effects of a prolongation of the actual times of payment from three months, as stipulated in the contract, to six months, in the same hypothesis of financial capacity of the contractor as in the previous case.

Also in this case, starting from the seventh month, the progress starts to be conditioned from the financial requirement and then becomes discontinuous.

But, to difference of the preceding case, the contractor is able to complete the works, although with some delay as well as a deterioration of the profit contribution.

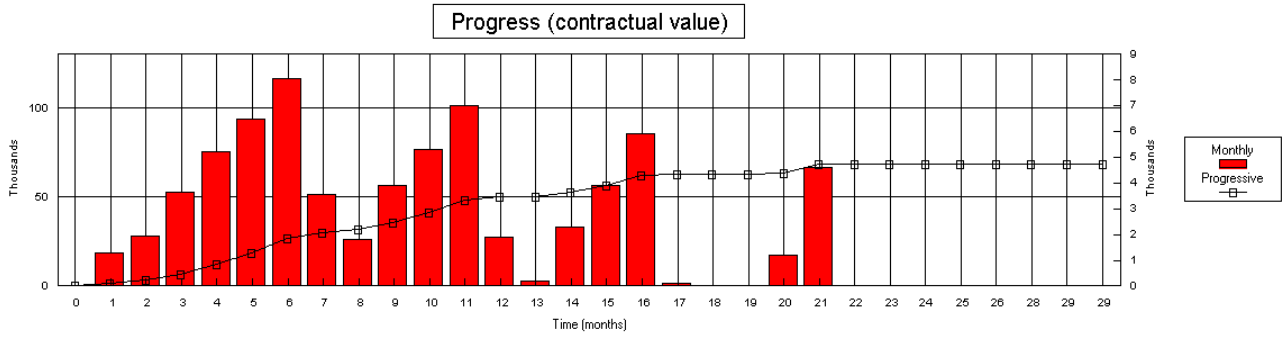
	Millions ECU	Ratio
Contract amount	130000000	100.00%
Direct costs	78000000	60.00%
Project overhead costs	30200000	23.23%
Total costs (direct + overhead)	108200000	83.23%
Profit contribution	21800000	16.77%
Contract amount to total project costs (k)		1.201
Overhead to total costs		27.91%
Financial requirements, maximum	17279000	13.29%
Financial requirements, average	15288000	11.76%



g) Disruption due to combine economic and financial causes

The further simulation is referred to a combination of economic and financial causes. The results are catastrophic and we believe that no comment is required.

	Millions ECU	Ratio
Works performed	68300000	
Direct costs	40980000	60.00%
Project overhead costs	39800000	58.27%
Total costs (direct + overhead)	87610000	128.27%
Profit contribution		
Contract amount to total project costs (k)		0.871
Overhead to total costs		45.43%
Financial requirements, maximum	24730000	19.02%
Financial requirements, average	21626000	16.64%



h) Summary

The various simulations are summarised in the table below:

	Budget	Suspension 3 months	Low progress	Cost increase	Cost increase with financial limit	Payments delayed	General disruption
Contract amount ECU	130000000	130000000	130000000	130000000	130000000	130000000	130000000
Works performed ECU	130000000	130000000	130000000	130000000	110300000	130000000	68300000
Time for completion (months)	18	21	21	18	unknown	24	unknown
Direct costs ECU	78000000	78000000	78000000	78000000	66180000	78000000	40980000
Project overhead costs ECU	23800000	29700000	38200000	32200000	39800000	30200000	39800000
Total costs (direct + overhead) ECU	101800000	107700000	116200000	123200000	117010000	108200000	87610000
Profit contribution ECU	28200000	22300000	13800000	6800000		21800000	
Contract amount to total project costs (k)	1.277	1.207	1.119	1.055	0.951	16.77%	0.871
Overhead to total costs	23.38%	27.58%	32.87%	26.14%	34.04%	1.201	45.43%
Financial requirements, maximum	14575000	15398000	9253000	27955000	20635000	17279000	24730000
Financial requirements, average	809000	2252000	4891000	13617000	18127000	15288000	21626000

Please note that direct costs have been considered depending only on quantities installed. This is not completely true since, when situation leading to future disruption start to rise, the works are generally performed with lower efficiency. By this way, also direct cost can increase making the situation worst.

D. A real example: the rescue of a French firm of the 1997.

D.1. Description of the plan

The facts we describe here started in September, 1996 up to June, 1997.

The Author was called as consultant, due to his experience and qualification in Total Cost Management, to cooperate in a project whose purpose was to avoid the disruption of a project and of a company as a whole.

The project ended with a success: in fact, to the project was completed with a delay of few week and with limited increase of costs, although the situation of the company was extremely difficult, as shall be explained below.

The project under consideration was relevant to the construction of a plant for the auto industry in an Asian country.

The Owner had stipulated a turn-key contract with an engineering & construction company specialized in plants for the auto industry that, in turn, had subcontracted,

with authorized or nominated subcontracts, the parts of the plant to other duly specialized firms.
Particularly, our subcontract was relevant to the internal transport and moving system. Basically, this plant consists of a series of rolling tables, elevators, wheels and other devices that allow the cars to me moved through the assembly line. The amount of the subcontract was equal to 36.900.000= DM

D.2. Main Contractor

The Main Contractor was a German engineering & construction company specialized in plants for the auto industry. The firm had an interesting mixed organisation structure, with a

- Commercial Department, whose job was looking for new markets, bidding and negotiating till the contract signature; the Department included for an own Preventive Section,
- Engineering Department,
- Procurement Department,
- Production Department, whose job was to coordinate the construction sites and,
- Technical Assistance Department.

The project management was within the Engineering Department, entrusted to Project Managers that were also responsible for the engineering itself.
When the project started to be under disruption, the project management was directly put under the responsibility of the Chairman.
It was in this phase that the author was called, by the Chairman, as adviser.

D.3. Subcontractor

Middle sized French company, with mixed characteristics between manufacturing firm and engineering; organisation structure rather irregular.
The state of crisis of this company did not derive from organisation problems, but from the market, namely due to low sales.
From the organisation charts we note that the Company was divided into:

- Installation Department (construction sites, stores, equipment, commissioning),
- Commercial Department, organised by market areas,
- Technical Department, subdivided into
    - Engineering Section (by products),
    - Automatic System Section
- Administration Department, that was an anomalous area in charge for accounting and bookkeeping, procurement and logistics.

The firm experienced, starting from 1996, a progressive deterioration of the market share and decrease of sales that determined a situation of disruption.

D.4. Disruption

a) Necessity of interfering

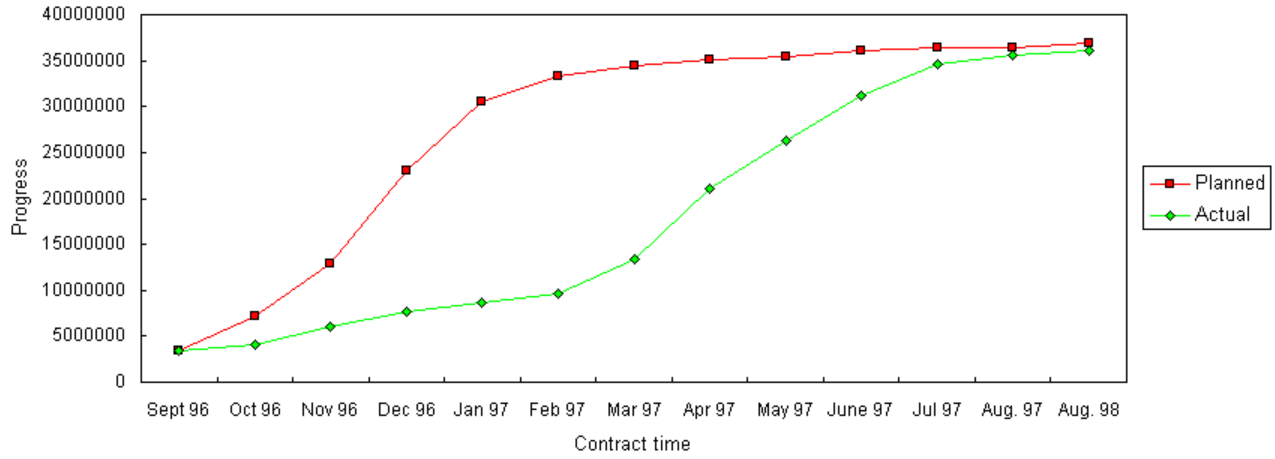
Useless to say that, in September 1996, there was a need for an energetic intervention in the management of the subcontract, in order to ensure its running and completion.
One of the first points to be considered was how to calculate the progress of the works in a way as more possible objective, taking into consideration, up to then, no reliable system of controlling the project was in operation.
We could easily consider the financial data as an indicator of the progress, but we had to compare such data with which technical and economic figures

It would have been helpful to have a technical progress report, but no one was available. No information about the work-load was available.
The only reliable data we could draw from cost accounting, namely:

- budget,
- monthly actual costs.

We then considered a **virtual work-load** in order to be able to calculate an indicative progress.
b) First phase: financial assistance and control of plan
The first phase of the operation began in October, as soon as it was evident that the Subcontractor was not anymore in a position to go on with the works efficiently. The progress started being in delay, and from our information it was clear that the causes were only of financial nature.
The visit to the subcontractor's factory and offices confirmed what we already knew. At that time, the subcontractor had received only the advance payment as per contract. Our choice was between stop the contract or help it.
Apparently the easier choice, from Owner's point of view, seems to stop payments and of adopt a line of total closure. Unfortunately, that would lead to complete disruption of the project, severe delays, penalties, etc.
This is why we decided to help the Subcontractor that we basically trusted although we understood that their difficulties were even more severe than we could know. In fact, without a trusting relationship our plan to rescue the project would have been impossible.
This first financial help, namely a second advance payment, did not give the results we hoped. It she was of fact totally absorbed from the fixed costs and did not have any positive result on the progress of the works.
i) Second phase: control and management of the project
At this point, we had to make a further decision: although continuing to support the subcontractor, we needed to put ourselves in a condition to be sure that our money would have been used only for the project.
Therefore, in accord with a French bank, we defined a procedure allowing us to have in our hands the control of the payments to the project suppliers. The subcontractor gave each week the list of the suppliers to be paid and we sent the relevant money directly to the said Bank. Please note that our problem was not of lack of trust in the subcontractor, on the contrary it was to put the subcontractor in a position to cope with its contractual obligations, resisting the other pressures that it could have received from other creditors.
f) Third phase: administration
By the end of December, the subcontractor was declared, from the Court of Commerce, under administration (*rédressement judiciaire*). In this case, the administrator put in charge by the Court agreed to continue with us using the procedure already in operation.

The final result, as shown in the graph below, was that the project was completed with few weeks of delay and with a tolerable increase of costs; besides, from the administration it has been possible to rescue at least some branches of the company that could remain active under a different name.



Conclusions

It can clearly be seen, from the examples above brought again, that, facing a situation of disruption, the only remedy allowing to go on with the project and, in some case, to reduce the damages, is to remove the technical and economic causes, as well as to inject cash in the project.

The temptation, for the disrupted contractor, is to compensate the cash flow of the project under disruption with the financial flows of the other project. Such compensation can succeed in few cases, if performed with rigor and knowledge of cause, in a firm in expansion.

For the Owner, the breach of the contract is a disaster that gives birth to costs that the contractual bonds cannot cover. The costs in fact do not derive only from the interruption of the jobs and from their direct consequences, but also from

- the delayed starting of the production of the plant,
- the extra-costs for stipulating a new contract for completing the plant.

In each case, the relationship between Owner and Contractor is completely different from the normal intercourses between customer and supplier; it is common interest of the parts that there is a system of project control, definite and approved from both parts, in order to monitor and keep under control the project.