

Securing of supply chain in aeronautic industry

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Projiris

- Limited company, created in 2004, 3 associates
 - CEO: Philippe Stollsteiner,
 - Headquarters at Plaisir (Near Versailles)
 - Activity:
 - 75% Project management assistance for SME's
 - 25% Consulting and training Analyse des risques (Industriels et financiers)
 - Risk analysis clients:
 - Nuclear sector: CEA
 - Railway infrastructure: RFF, Inexia
 - Traffic forecast studies: Egis mobilité,
 - Food safety: AFSSA
 - Aeronautics, Defence: Thales Communications, Thales Systemes
- Aéroportés.



Context of the present case

The client:

- An international aeronautic electronic system integrator. More precisely, the industrial direction department in charge of methodology.

The request:

- To provide a **methodology** and **tool** to determine the optimal security stock for electronic boards production.

At stake:

- Penalty in case of late delivery
- Cost of an excess of electronic boards stock

Context of the present case

The products:

- The products consist of electronic boards to be integrated in racks.
- These racks, once tested with their boards are delivered to the aircraft manufacturer.



Methodology proposed

Qualitative risk analysis:

What are the main risk drivers for late delivery?

Interviews have been made of key stakeholders:

Industrial director, purchaser, supply chain manager.

Quantitative risk analysis:

Are they statistics available for late delivery?

Are they statistics available for faulty boards?

Qualitative analysis results

The main risk drivers were found to be:

- **Overall punctuality rate** of the supplier. The risk **impact** is the number of weeks of delay.
- The **failure rate** of boards delivered. The risk **impact** is the number of weeks to get the board repaired.

For both rates, there are statistics available within the company.

Model building

Model building/ Objectives

Delay and failure modelling intervening on electronic boards delivery implies modelling the return in stock of delayed or faulty boards.

The programming of this modelling with Excel formulas is quite delicate, particularly when the delay value can take very different values.

As a first step, the value of the delay for return in stock of delayed or faulty boards is simplified to 2 possible values.

The model settings are related to the AXB24 board.

Model building/ Objectives

8				W01	W02	W03	W04	W05
9	AXB24 board	-						
11	Security level	9	100%	100%	78%	67%	44%	56%
12	Stock	St	9	9	7	6	4	5
13	Gross Production from supplier	Pbr		7	7	7	7	7
14	delayed quantity	Pret	9	0	1	1	1	1
15	Delivery delay from supplier	Ret		3	3	3	1	2
16	Shifted delivery	Pdec		0	0	0	0	2
17	Actual delivery from supplier	Pnt1		7	6	6	6	8
18	Faulty boards qty	Ppan		0	1	0	1	0
19	Delay for repair	Rep		4	4	4	4	4
20	Return from repair	Prep		0	0	0	0	0
21	Net supplier Production	Pnt		7	5	6	5	8
22	Scheduled delivery to client			7	7	7	7	7
23	Livraison réelle client	Pliv		7	7	7	7	7

Example: The delayed quantity in Week 2 is of 1 unit, and the delay value is 3 weeks. The delayed quantity in Week 4 is of 1 unit, and the delay value is 1 week. So , in Week 5, 2 boards will be delivered in addition to the normal delivery. We have to select the week pointed by the delay value to calculate the shifted delivered production. This calculation is done by using Excel formulas. See in Appendix detailed formulas.

Model building (1)

We have to simulate 2 kinds of risk events:

- Delivery delays
- Faulty boards

The supplier weekly net production, P_{nt} , is calculated in 2 steps :

- Subtraction of delayed boards, P_{ret} , from gross production, P_{br} , and sum of boards delivered in shifted delivery, P_{dec} . We obtain P_{nt1}
- On the boards really delivered, subtraction of the faulty boards,, P_{pan} and sum of repaired boards, P_{rep} . We obtain P_{nt}

$$P_{nt} = P_{br} - P_{ret} + P_{dec} - P_{pan} + P_{rep}$$

Model building (2)

The number of delayed board, P_{ret} , is calculated from the delay rate, T_{ret} , with the binomial statistical function.

$$P_{ret} = \text{RiskBinomiale}(P_{nt}; T_{ret})$$

The delayed boards are delivered, with a variable delay, Ret , such as:

- 1 week delay in 1/3 occurrence
- 3 week delay in 2/3 occurrence

$$Ret = \text{RiskDiscrete}(\{1; 3\}; \{0,33; 0,66\})$$

From this definition of delay, we calculate the shifted production with Excel formulas, P_{dec} . The production actually delivered is:

$$P_{nt1} = P_{br} - P_{ret} + P_{dec}$$

Model building (3)

The number of faulty boards, P_{pan} , is calculated from the failure rate, T_{pan} avec la fonction statistique binomiale.

$$P_{pan} = \text{RiskBinomiale}(P_{nt1}; T_{pan})$$

The repaired boards are delivered after a repair delay, Rep , such as:

- Return after 4 weeks with a 85% occurrence
- Return after 5 weeks with a 15% occurrence

$$Rep = \text{RiskDiscrete}(\{4; 5\}; \{0,85 ; 0,15\})$$

From this repair delay, we can calculate with an Excel formula the number of repaired and reintegrated boards, P_{rep} . The actual delivered production to the client is:

$$P_{nt} = P_{nt1} - P_{pan} + P_{rep}$$

Model building(4)

Instantaneous stock calculation:

The stock in week « n », $St(n)$ is calculated from the stock in week « n-1 » increased by the net delivered production from the supplier, Pnt , and decreased by the quantity delivered to the customer, $Pliv$.

$$St(n) = St(n-1) + Pnt - Pliv$$

One model parameter is the initial **stock**, $St(0)$.

Simulation with AXB24 board model settings

AXB24 board model settings

Simplifying assumptions:

- The 2 types of risk are supposed to be independent. (Non punctuality not correlated to failure rate)

Faulty boards

- Failure rate 4,5%. Faulty boards come back repaired within:
- 4 weeks in 85% of cases (Simplifying assumption)
- 5 weeks in 15% of cases (Simplifying assumption)

Delivery delay:

- Punctuality is mainly **90%**
- 6% of boards are delayed by one week (Simplifying assumption)
- 94% of boards are delayed by three weeks (Simplifying assumption)

Quantity to be delivered by the supplier

- 7 units per week.

Quantity to be delivered by the client:

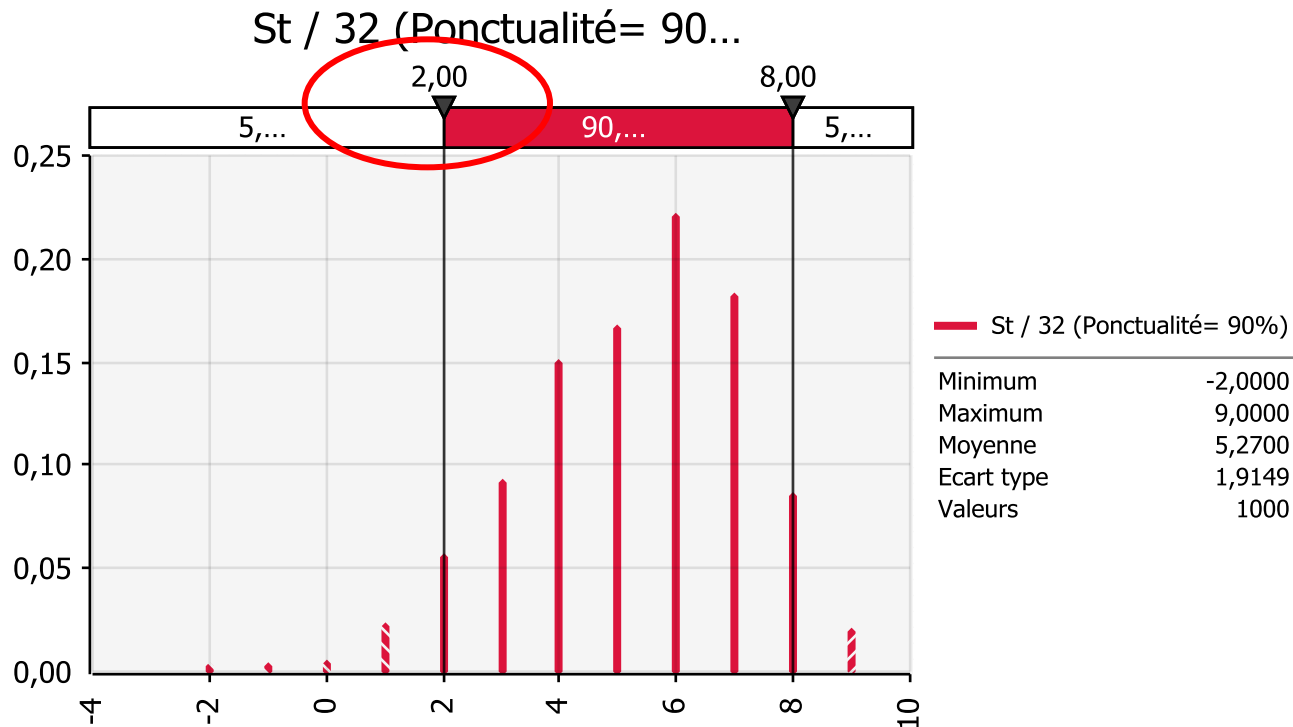
- 7 units per week

Stock initial:

9 units, which means a little more than one week of production

Simulation result (1) AXB24 board

Stock value in week 32



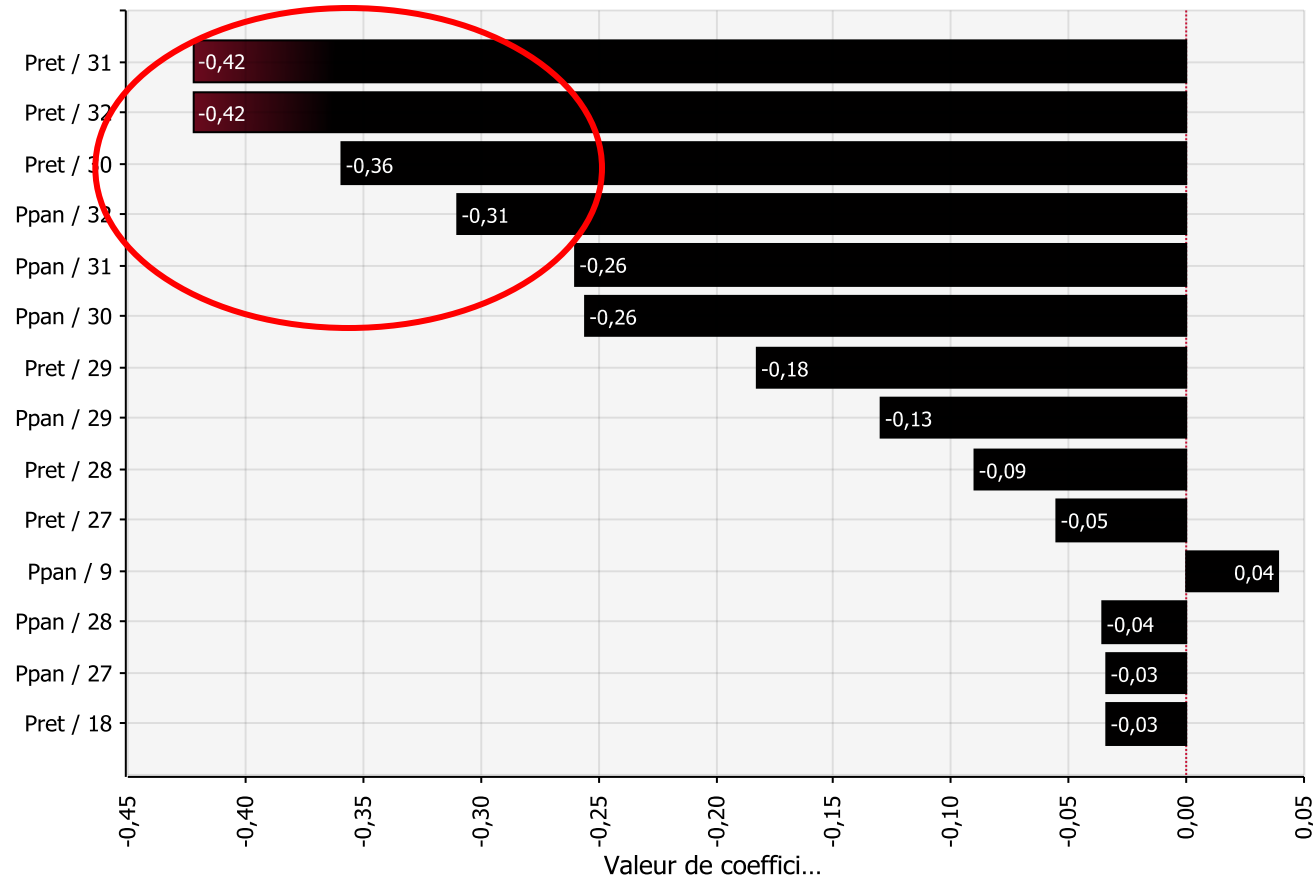
Initial stock in week 0 is 9 units.

Taking in account the identified risks, the stock can decrease to **-2**, which means break in the delivery. There is 5% chance that the stock will be less or equal to 2 units.

Simulation result (2) AXB24 board Sensitivity analysis

St / 32 (Ponctualité= 90...

Coefficients de régressi...

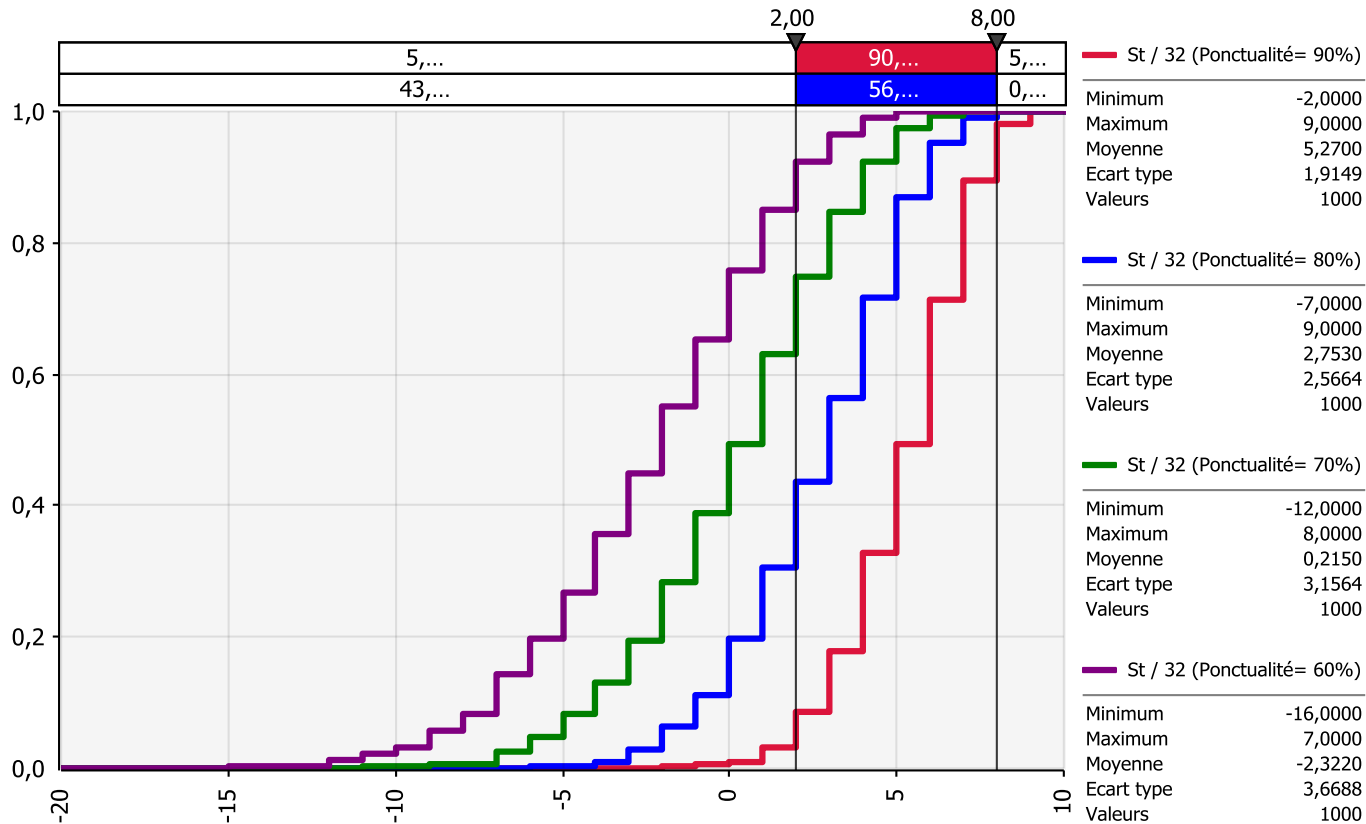


With the simulation settings, this is the risk linked to to the punctuality which is most important. (Pret = Delayed production). Followed by the quantity of faulty boards (Ppan)

Simulation results (4)

Multiples simulations. Influence of punctuality

St / 32 (Toutes les simulatio...

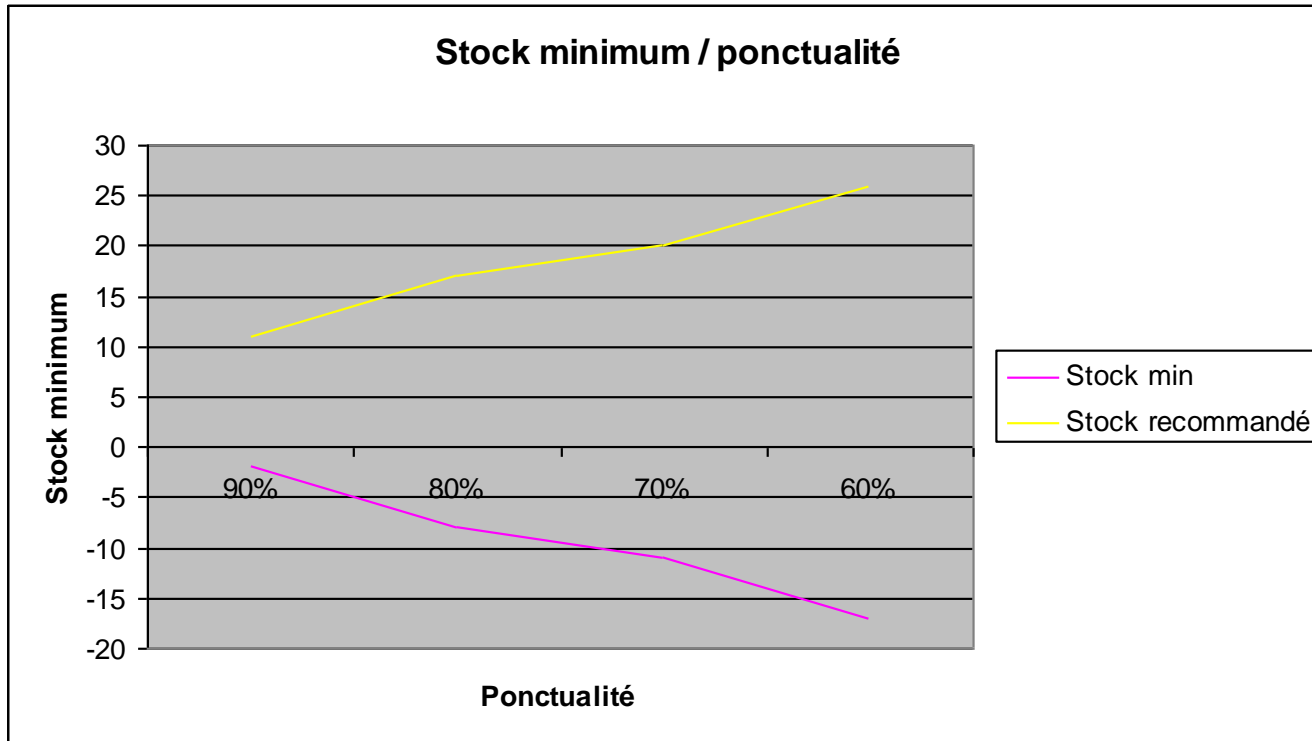


Minimum stock pass from -2 to -7, then -12 et -16 , this for an initial stock of 9 units.

We see that the standard deviation changes from 1,9 to 3,6 indicating a raise in risk.

Simulation results (5)

Multiples simulations. Influence of punctuality



The **recommended stock** is the difference of the minimum stock with the initial stock. This one changes from 11 to 26 when the punctuality decreases.

Discussion

What about the influence of extreme value of delay ?

Influence of extreme values

This first set of results was obtained with simplifying assumptions:

- The delivery delay could take only 2 values: 1 week or 2 weeks
- The time to repair could take only 2 values: 4 weeks or 5 weeks

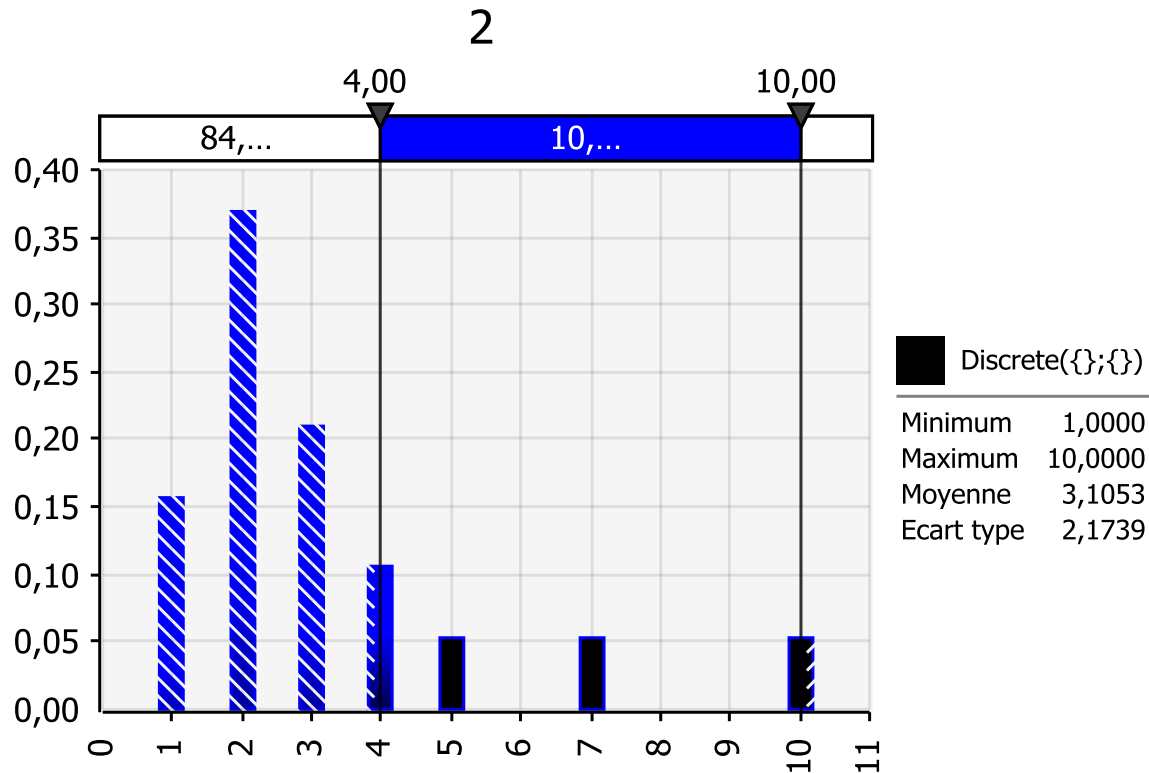
In reality, the distribution of delay values can take a lot more values, including extreme values.

Quantity delayed	3	7	4	2	1	0	1	0	0	1
Delay value (weeks)	1	2	3	4	5	6	7	8	9	10

It may be interesting to check if the results regarding the optimum stock are changed by taking in account a more realistic distribution.

Influence of extreme values

The different frequencies can be modelled by a discrete function



Influence of extreme values

But, at this point, there is a problem:

As it was not too difficult to create Excel formulas for 2 values of delay, it becomes a nightmare, (and a source of errors) to create Excel formulas for 10 or more values of delays.

Excel formula for 2 values of delay:

```
=SI(ET(M15=1;K15=3);M14+K14;SI(K15=3;K14;SI(M15=1;M14;)))
```

Why not to use VBA macros to make this calculation?

Simulation Result comparison

2-value delay/delay with extreme values

The table below compares simulation results obtained with a 2-value delay and the one obtained with a delay including extreme values. We see that:

- For good punctualities (90%), the simulation results are similar.
- For bad punctualities ($\leq 80\%$), the results differ.
- **The minimum values of stock are 50% higher than in the first case, thus needing a more important security stock.**

Punctuality	2-value delay		Retard with extreme value	
	min	5%	min	5%
90%	-2	2	-2	2
80%	-5	-1	-7	-2
70%	-7	-3	-12	-5
60%	-10	-5	-16	-9

Conclusion

On the AXB24 board, the security stock (9 units) is insufficient, taking in account the punctuality and quality parameters. Moreover, if punctuality decreases below 80%, the stock should be increased to 20 units (70% punctuality) and to 26 units (60% punctuality)

Interest of taking in account the extreme values in delay (and repair time) modelling:

The extreme values of delivery delay decrease significantly the minimum values of stock and hence increase the need for security stock. So they must be taken in account in the model. The use of VBA macro instruction allows it..

Model reliability

When tuning the model, we compared the results of the simplified model with and without macros. This allowed to find out mistakes in the model formulas, and exclusively in the model without macros (Mistakes in copying/pasting of formulas). The model with macros was found more reliable.

Conclusion/ the client reaction

The client was closely associated to the study.

They agreed to the added value of the simulation results in order to determine the optimum stock for a specific board.

But they were cautious regarding using this tool in the production process.

Obstacles are:

- Availability of the right statistics in the right format to feed the model.
- Big number of references (board models) involved in the process.

One way of using the tool would be to create a procedure giving recommendations and charts for determining the optimum stock.