



# **Advanced M&S applied to Analysis Techniques for Supporting Decision Makers in Multi-Job Management in an Aeronautical Industry**

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# Goals of the Research

The main goal of the Research is to reduce the Assembling Line Lead Time. In order to reach this goal is requested to:

- Identify and Analyze Criticalities
- Reorganize all the Phases of the Production Process
- Evaluate the Impact of all the Stochastic Phenomena

# First Hypothesis of Assembling Line Lead Time Reduction

	operai/giorni	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Squadra A				Squadra B								
1°Turno	1	6	6	6	6	6	6	11	11	TEST WEE			17	17	23	23	23	23	23	23	23	23	Bidone	Garbati										
	2	8	8	8	10	10	10	11	11				17	17	23	23	23	23	23	23	23	23	D'Agostino	Salvador										
	3	9	9	9	9	9	9	9	9		9	9	9	9	18	18	18	18	18	18	18	18	Zone	Cecchini										
2°Turno	4	12	12	13	13	13	13				24	24	24	24	23	23	23	23	23	23	23	23	Canepa	Fois										
	5	12	12	13	13	13	13				24	24	24	24	23	23	23	23	23	23	23	23	Astengo	Macciò										
	6	15	15	15	10	10	10	14	14		14	14	14	14	34	34	34	34	34	34	34	34	Gaggero	Palladino										
										1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20					
	Predisposizione Modifiche	6	50 ore 1pers								1	1	1	1	1	1			TEST WEE															
	Installazioni Portelli	8	25 ore 1 pers								1	1	1																					
	Installazione Canard	9	110 ore 1pers								1	1	1	1	1	1	1	1		1	1	1	1											
	Assy portelli principali e posteriori	10	50 ore 2 pers										2	2	2																			
	Installazione portello bagagliaio	11	35 ore 2pers													2	2																	
	Installazione particolari fuori scalo	12	25 ore 2 pers								2	2																						
	Predisposizione bulbo deriva	13	60 ore 2 pers										2	2	2	2																		
	Predisposizione poppino	14	50 ore 1 pers													1	1			1	1	1	1											
	Installazione antenne	15	24 ore 1 pers								1	1	1																					
	installazione pinne	17	35 ore 2 pers																		2	2	1	1	1	1	1	1	1	1				
	Raccordo ala fusoliera	18	50 ore 1 pers																															
	installazione Flap	23	200 ore 4pers																					4	4	4	4	4	4	4				
	Installazione alettoni	24	60 ore 2 pers																2	2	2	2												
	Verniciatura basico	34	58 ore 1pers																				1	1	1	1	1	1	1					
										6	6	6	6	6	6	4	4	0	0	4	4	6	6	6	6	6	6	6	6					

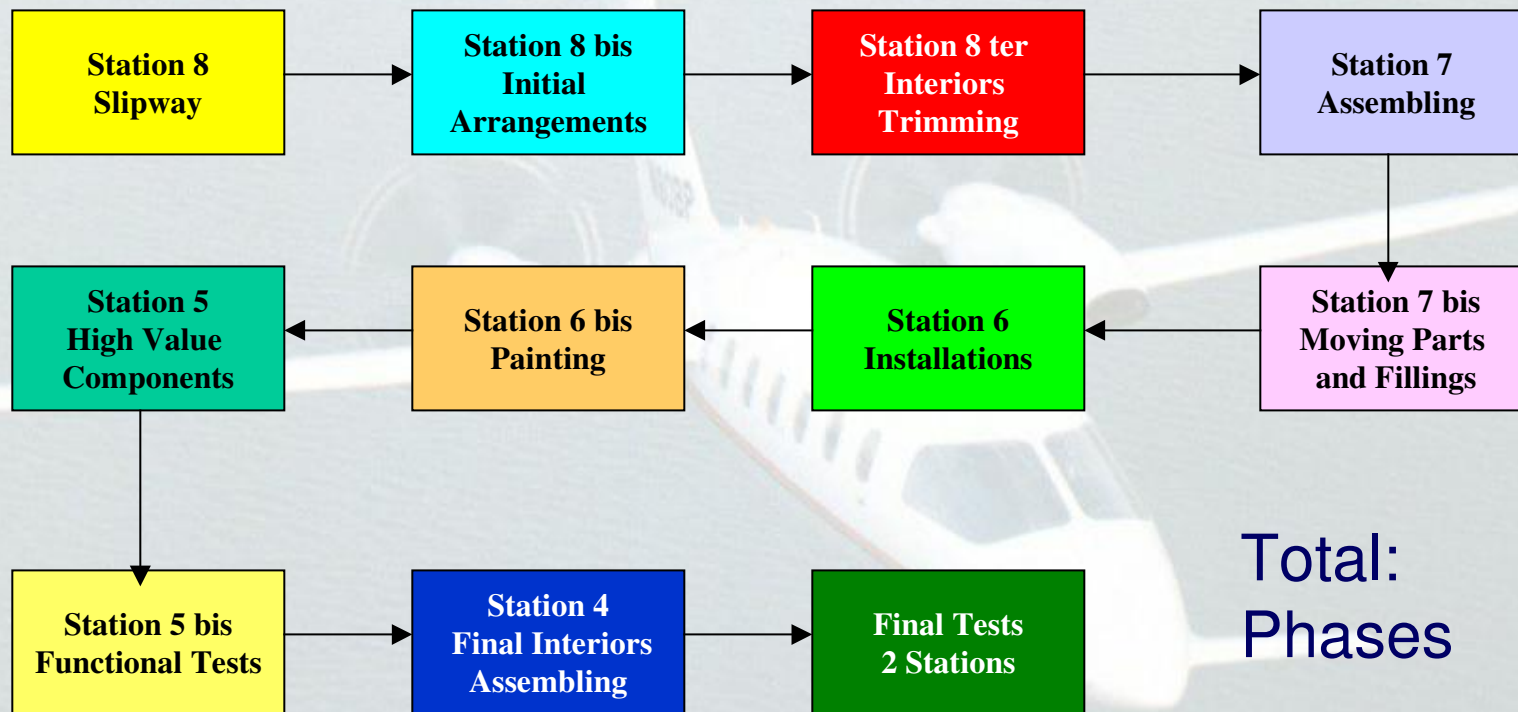


•Data have been Modified due to their Confidential Nature

# Methodology

- Build Simulators and Models devoted to analyze Risks and Criticalities
- Development and Analysis of the Assembling Line Systems in order to:
  - Reduce the Aircraft Mean Lead Time from 6 to 4 Months
  - Reduce WIP
  - Decrease the Number of Aircrafts simultaneously present in the Assembling Line
  - Save a significant amount of Money in terms of Banking Interests
  - Distribute better Resources on Planes
  - Have a Positive impact on the Company Cash Flow

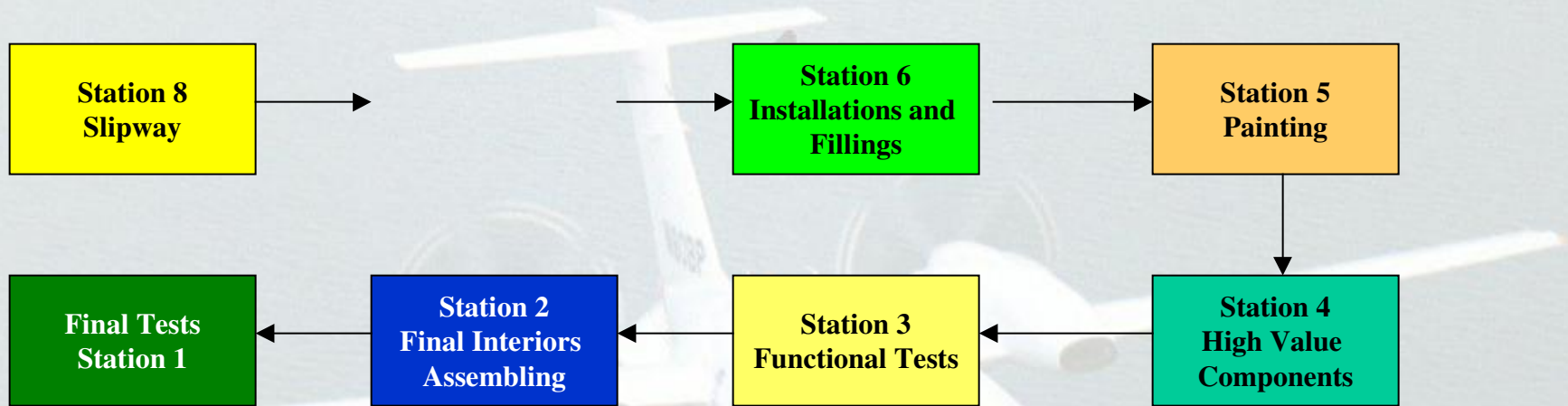
# The Present Productive Processes



Total: 12  
Phases

LT = 24  
Weeks

# New Assembling Line



Total: 8 Phases

LT = 16 / 18 Weeks

# Departments to be Reengineered

- Assemblers' Dept.: Code 742
  - Carpenters
  - Fillers
  - Commanders
  - Planters
  - HVAC
  - Assemblers
- Electricians' Dept.: Code 744
- Interiors' Dept.: Code 745
- *Painters' Dept.: Code 743*

# Data Collection

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10.10.8.1 - A - TCP660
File Modifica Visualizza Comunicazioni Assegna Stampa ?
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SITUAZIONE TEMPI P/N: 80TESTWEE-BASE SUP: DATA 27/08/04 ORE: 11.35.33
DATI ORDINATI PER DATA LAN. ==>DES.P/N: TEST WEE X VELIVOLO BASE <==P. 01
-(AP2= Aiuto e SIO= Tel.8534)---(Coll.:F1=GO46,F2=GO35,F4=RO00,F6=GO06,F10=OM50)-
NUMERO ST. NUMERO M. Q.Tà !SIT. OPER.!SITUAZ. BOLLE! TEMPO ASSEGNATO ! TEMPO
ORD/M. OM COMM.O/L. V. LAV. ! CHI. TOT.! AP. CH. TOT.! TOTALE PARZIALE!SEGNATO
845348 50 22177 1072 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
848374 50 22178 1071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00050,50
852738 50 22179 1071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
854222 50 22181 1071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
856486 50 22180 1071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
860667 50 22185 4071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
861278 50 22187 4071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
861717 50 22183 4071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
863598 50 22182 1071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
863599 10 22184 4071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,00
879169 10 22186 4071 T 0001 ! 000 0002 ! 001 000 001 ! 0051,00 0051,00 00037,00
887732 10 22188 4071 T 0001 ! 000 0002 ! 000 001 001 ! 0051,00 0000,00 00051,50
887733 10 22189 4071 T 0001 ! 000 0002 ! 000 000 001 ! 0051,00 0051,00 00000,00
893133 10 22190 4071 T 0001 ! 000 0002 ! 000 000 001 ! 0051,00 0051,00 00000,00
893134 10 22191 4071 T 0001 ! 000 0002 ! 000 000 001 ! 0051,00 0051,00 00000,00
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MA* a 10/002
  
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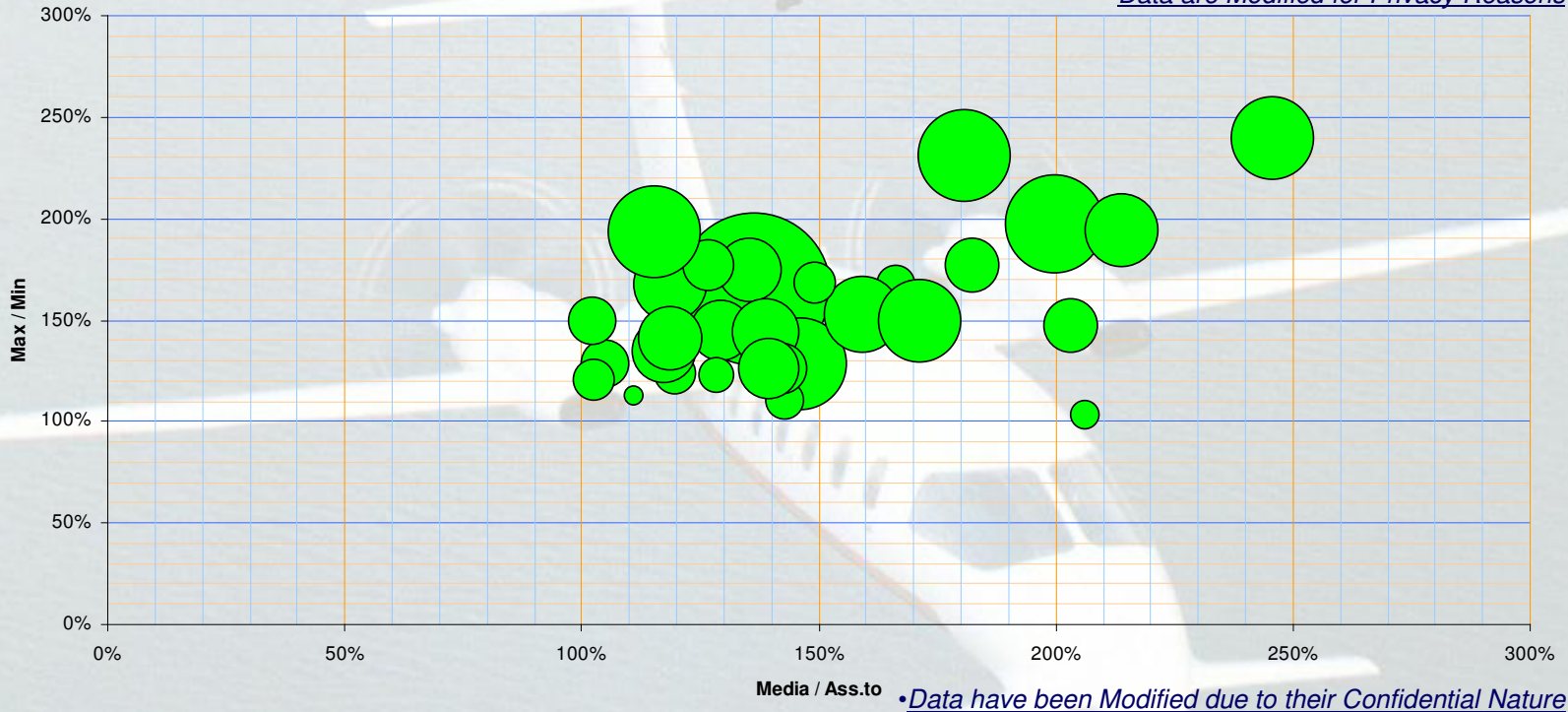
- Data were acquired by the Authors using the LAN-Based Company Informative System (CX)
- The Main Functions are:
- Inventory Status
  - Bills Control
  - Job Progress Control
  - Worked Hours Control



# Performance Analysis (Dept. 742)

Att. Rep. 742

*•Data are Modified for Privacy Reasons*



Mean Extra-cost for 742 Dept. Is 30% compared with Scheduled

# “Solar” Simulator

- VBA Simulator based on the real Job Completion Time
- Dates extracted from the Bills start and finishing time (CX)
- Mean Airplane Lead Time overestimated based on statistical analysis



- Necessity to validate data and to develop a more detailed model

# M.A.C.A.C.O. Simulator

- Stochastic Discrete Event Simulator
- Job Duration-Based historical data (from Aircrafts NC 1077 to NC 1086) and experts estimation by beta distribution
- Production Process Model using concurrent PERT for each plane considering resources and constraints
- C++ built and animated
- Stochasticity provided by different probability distribution; deterministic case is also allowed
- Allows formulating What-If Analysis on Criticalities and Bottlenecks by varying Input Data

# Modelling Air Craft Analysis for Construction process and Organization

**Interface allows to evaluate:**

- Job Status
- Production
- Real Time Lead Time
- Resource Saturation Level
- Utilization Coefficients
- Positions Saturation

Completed Airplanes: 19.0000 - Lead Time mean: 19.9708 [weeks]

0	2	20	3	4	13
98.2%	58.4%	27.6%	40%	54%	46.7%

4	3	5	3	28
60%	45.1%	79%	32.9%	6.7%

Gauge: 19.9708 [weeks]

by: A. Bruzzone, E. Briano, F. Longo

Copyright 2004 Liophant Simulation

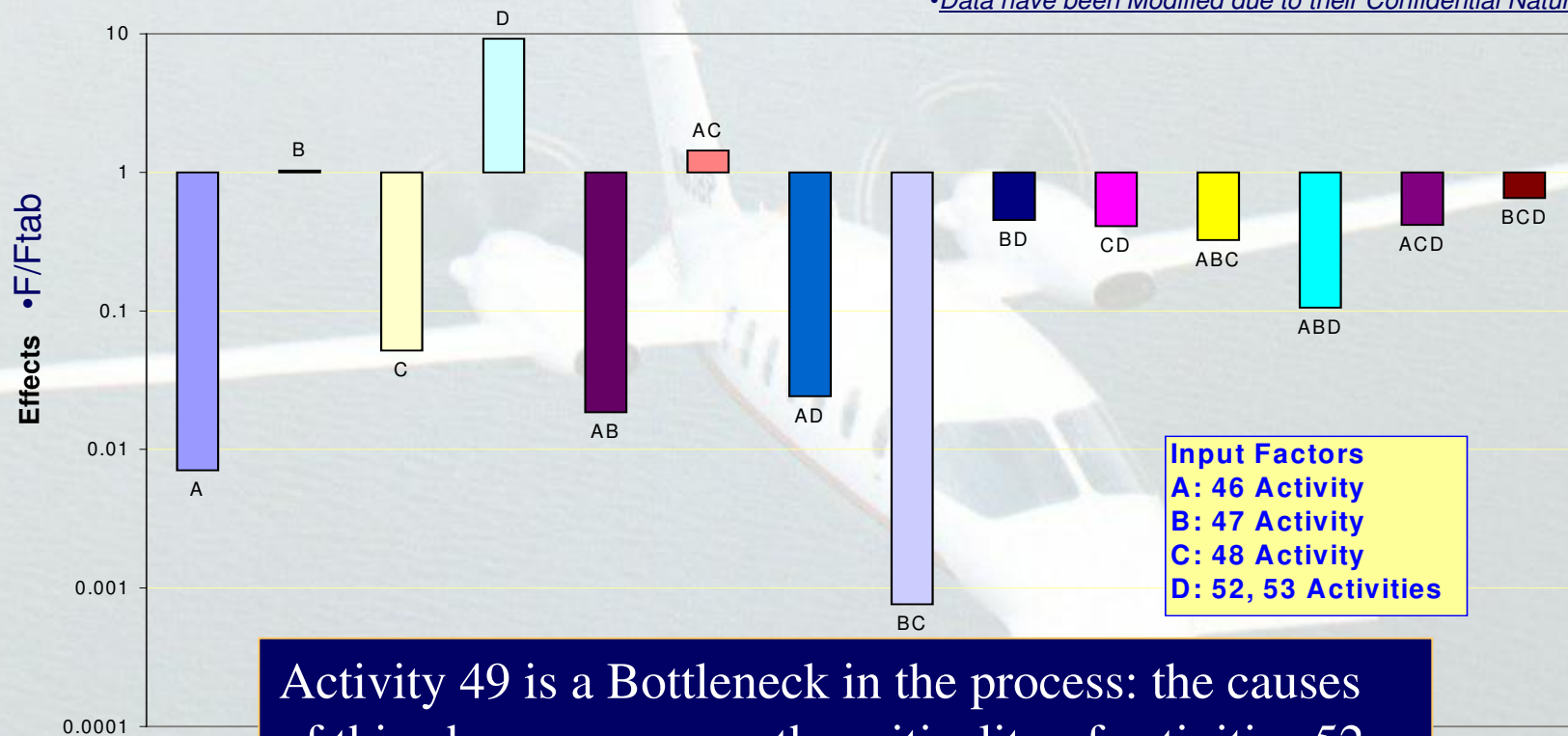
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Verbose
  Save File
  Limited Resources

# Bottleneck 49 Analysis (Test Press)

## Sensitivity Analysis: Bottleneck 49

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**Input Factors**  
 A: 46 Activity  
 B: 47 Activity  
 C: 48 Activity  
 D: 52, 53 Activities

Activity 49 is a Bottleneck in the process: the causes of this phenomenon are the criticality of activities 52 e 53 and the influence of the synergy of activities 46 and 48

# Sensitivity Analysis on Criticalities (1/2)

- 2<sup>6</sup> Factorial Project based on Critical Path Activities Duration and on the Number of Fillers and Assemblers

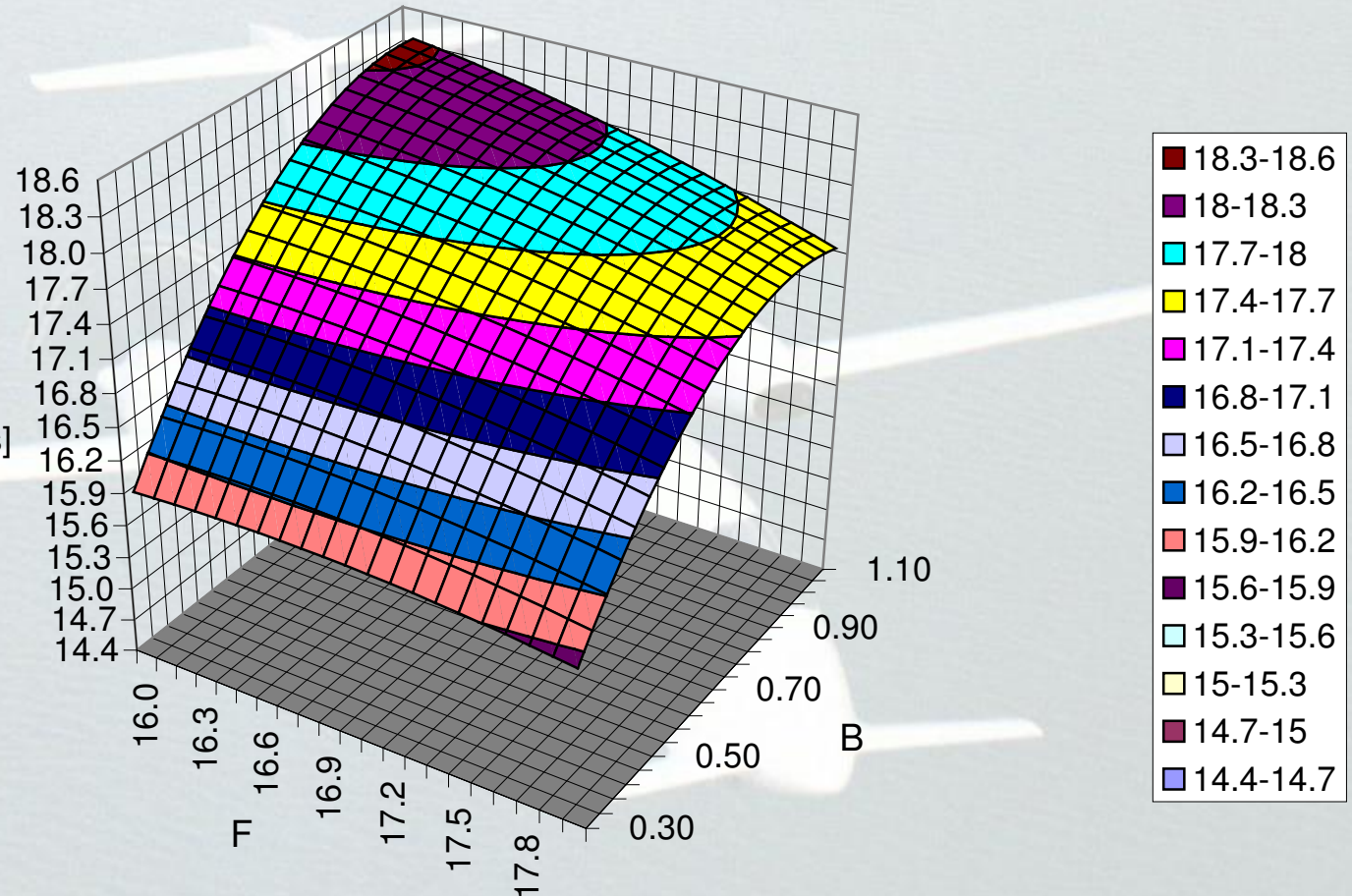
FACTOR	MIN	MAX
A: CRITICALITY DURATION COEFF. Station 8	60%	140%
B: CRITICALITY DURATION COEFF. Station 7	60%	140%
C: CRITICALITY DURATION COEFF. Station 6	60%	140%
D: CRITICALITY DURATION COEFF. Station 5	60%	140%
E: N° OF FILLERS	4	6
F: N° OF ASSEMBLERS	14	18



## Response Surface Methodology: Lead Time

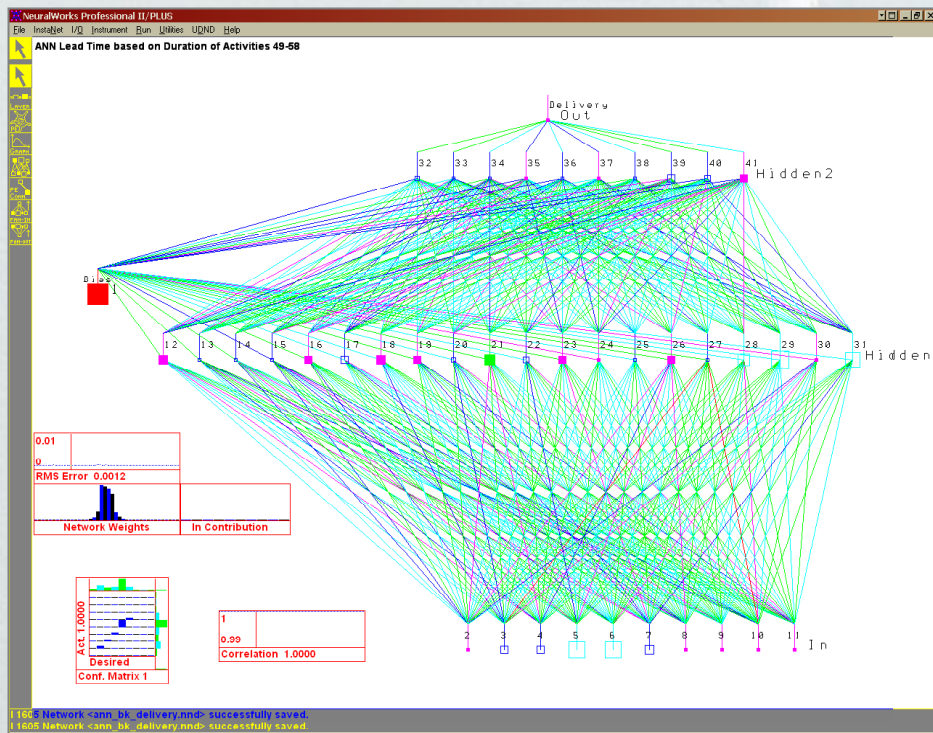
Local Best is at the minimum duration of Station 7 criticalities and at the maximum number of Assemblers

Plane Lead Time [weeks]





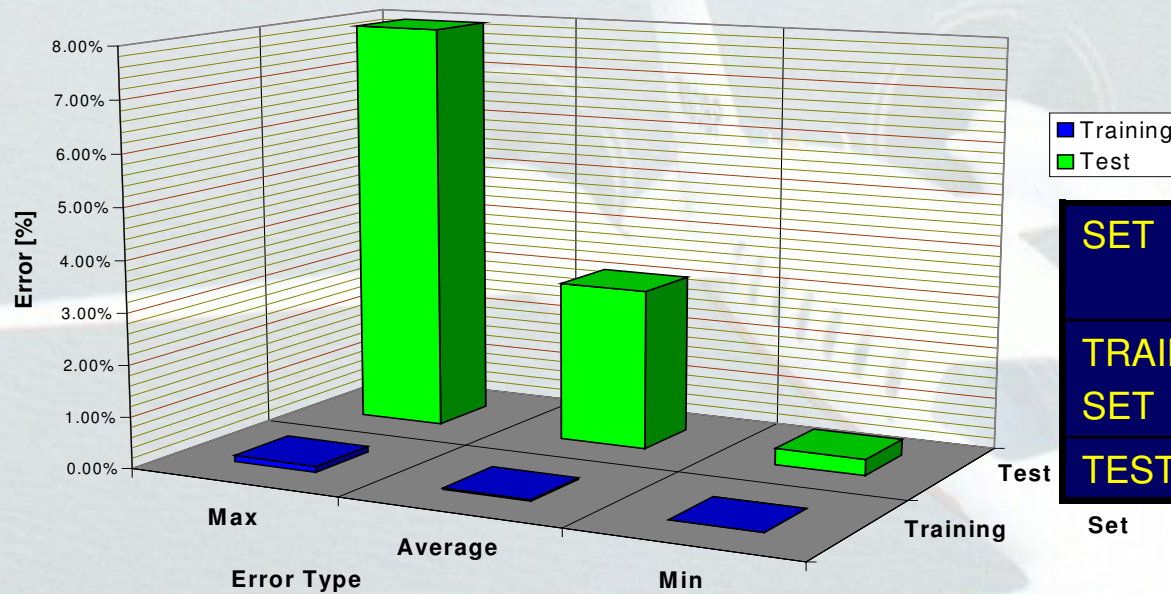
# ANN Methodology Applied to the Plane Delivery Date Analysis



- Full Connected Feed Forward Architecture
- Back Propagation Algorithm
- 23 runs during Training
- 23 runs during Test
- 10 inputs: from job 49 to 58 (Station 6)
- 2 levels hidden layers
- 1 output: Delivery Date

# ANN Methodology Results (1/3)

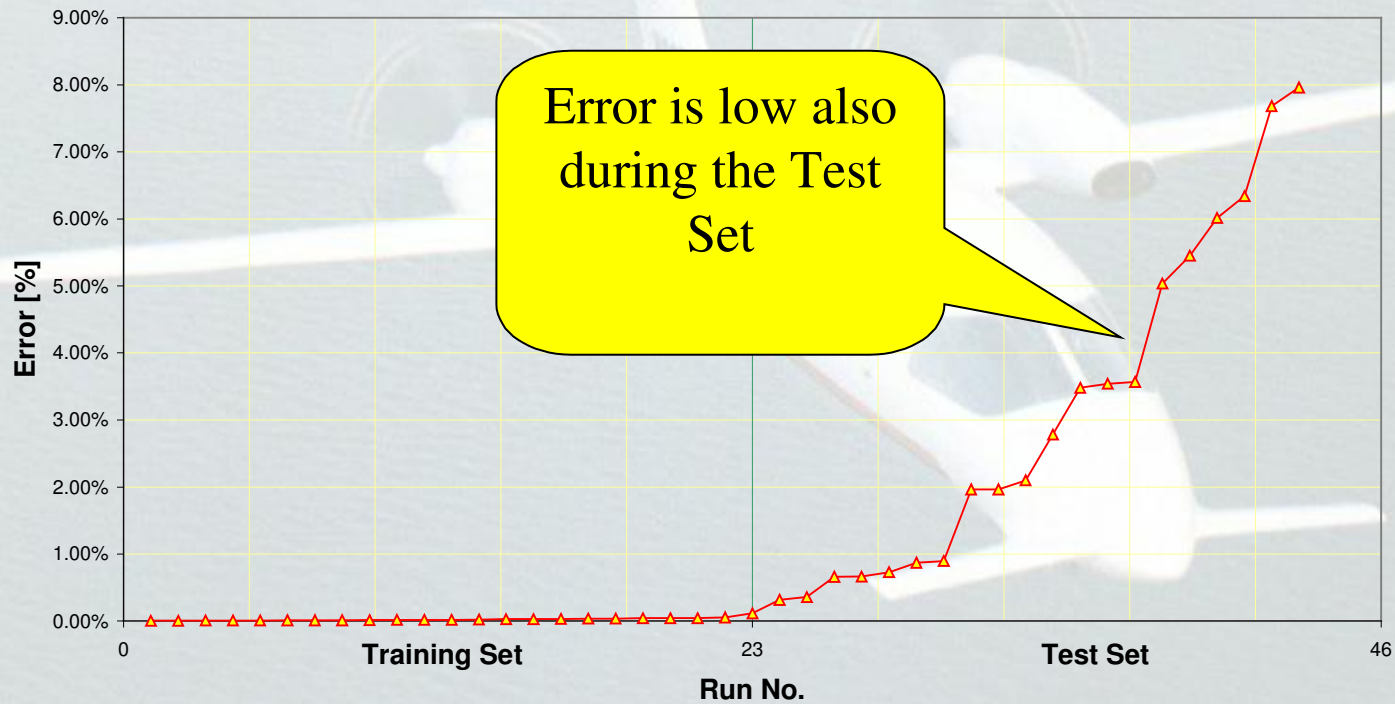
Errors for Prediction of Plane Delivery in the Different Sets



SET	AVG ERROR	MAX ERROR
TRAINING SET	$\cong 0$	0.11 %
TEST SET	3.12 %	7.96 %

# ANN Methodology Results (2/3)

ANN Error in Estimating Plane Delivery  
on Training/Test Data

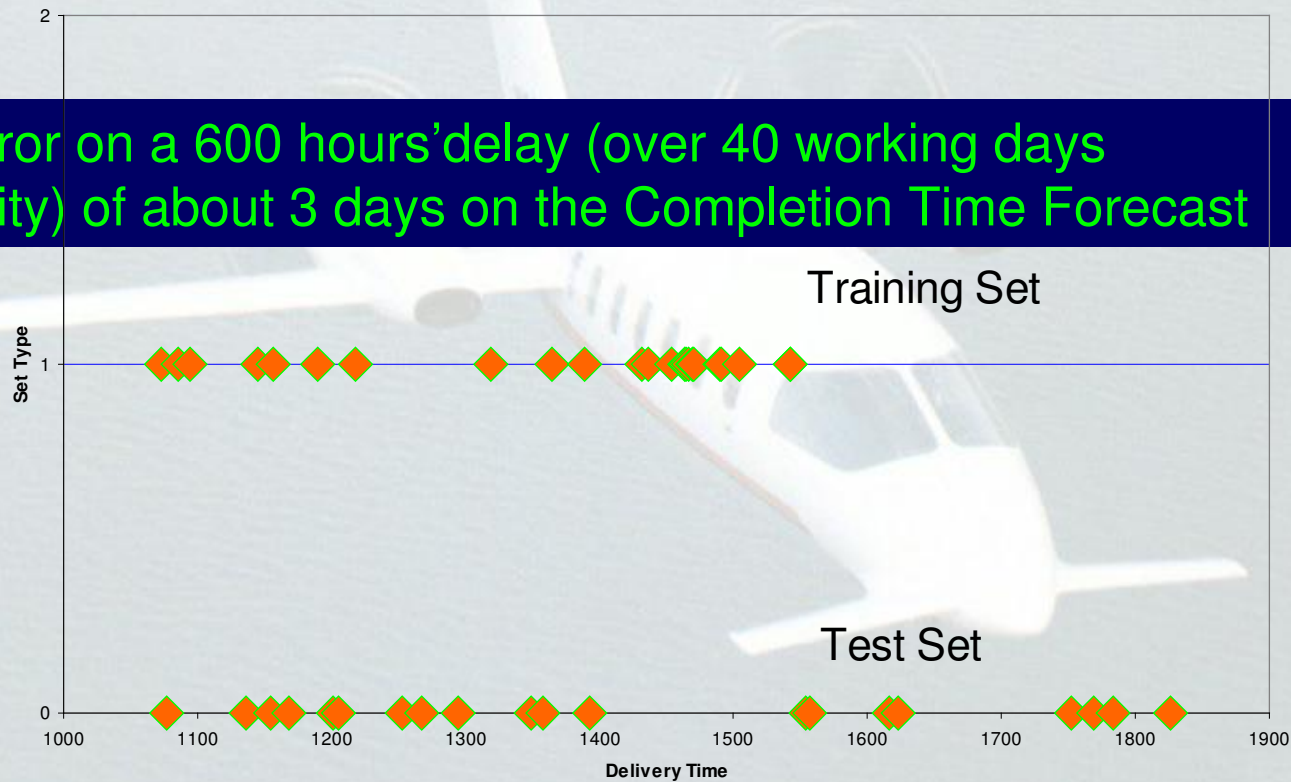


# ANN Methodology Results (3/3)

*•Data are Modified for Privacy Reasons*

## Delivery Times

Max Error on a 600 hours' delay (over 40 working days variability) of about 3 days on the Completion Time Forecast



# Conclusions

- Developed Simulation has been successfully validated on the P180 Assembling Line Scenario
- Simulation was able to identify a solution to guarantee 18 Weeks Lead Time without Manpower and Machinery Costs increase
- This Analysis has demonstrated the possibility of:
  - 15% WIP Reduction
  - 25% – 33% Off Planes inside the Assembling Line
  - Saving 21.5k€/Plane on financial fees