

## **The SIT activity to disseminate physical quantities in Italy : calibration of material testing machine intercomparisons**

Carlo Ferrero(\*), Luciano Bianchi (\*\*)  
Istituto Nazionale di Ricerca Metrologica (INRIM), Italy (\*)  
Servizio di Taratura in Italia (SIT), Italy (\*\*)

### **Abstract**

One of the most important activities at European (EA) and National level of the National Accreditation Body (NAB) is the organisation of a series of interlaboratory comparisons (ILC), to verify the measurements capability of the accredited Laboratories [1].

In 1999, 2001, 2002, 2004 four ILCs, for the calibration of material testing machines, was organised in Italy by SIT. In the present paper the main results obtained during the ILC are discussed, in particular a regression analysis was applied to evaluate the differences on the repeatability and accuracy given by the different laboratories

*Keywords:* calibration, testing machine, intercomparison

### **Introduction**

The Istituto Nazionale di Ricerca Metrologica (INRIM), provides traceability in Italy to the standards of mechanical, thermal, chemical and electrical quantities all over the country, so as to allow high-quality measurements and tests to be made /2,3/.

At present the number of SIT accredited Laboratories is 174 in total, 21 for force quantity (load cell, testing machines, impact pendulum and torque).

One of the most important activities of SIT-Servizio di Taratura in Italia, the National Accreditation Body (NAB), is the organisation of a series of interlaboratory comparisons (ILC) at national level, and to take part to the ILCs organised at European level by EA in order to verify the measurements capability of the accredited laboratories /4,5/.

In 1999, 2001, 2002, 2004 four ILCs, for the calibration of material testing machines, was organised in Italy by SIT with the INRiM (formerly IMGC-CNR) as reference laboratory.

### **General Evaluation**

One of the difficulties of one intercomparison on material testing machines (MTM) is represented by the big weight and large size of the equipments to calibrate, so it is difficult or impossible to have such equipments circulating. In this case each participating accredited Laboratories has to move to the location where the equipment is located. A second difficulty is that the object of the comparison (the material testing machine) is not a reference standard.

Several ILCs, for the calibration of material testing machines, was organised in Italy by SIT with the following purposes:

1. to give an experimental validation of the force dissemination in Italy;
2. to evaluate the calibration competence of the different laboratories;
3. to give a contribution to solve the problem for future international comparison for such kind of equipments.

### Material Testing Machines and Procedure

In order to evaluate in the better way during the ILCs the calibration capability of each Laboratory, MTM were chosen of different capability and different structure (two or three column), respectively:

In 1999 two materials testing machines (MTM) were chosen of 600 kN and 5000 kN rated load, located at the Politecnico of Torino, respectively:

- Type METROCOM (no. 6596/76) in traction and compression
- Type GALDABINI model PMC/500 (no. 19933) in compression (three ranges: 1000 kN, 2500 kN and 5 MN).

At the ILC-99 participated 4 SIT Laboratories with 20 reference force transducers.

In 2001 three MTM were chosen of 100 kN, 1000 kN, 5000kN rated load, located at the Politecnico of Torino and at the IMGCC-CNR, respectively:

- Type Instron model 8562 - 100 kN in traction;
- Type PMC 500 kN – 5 MN in compression (three ranges);
- Type PMC 100 kN – 1000 kN in compression (three ranges: 200 kN, 500 kN and 1 MN).

At the ILC-01 participated 8 SIT Laboratories with 53 reference force transducers.

In Table I is given, as an example, a summary of the ILC-01 intercomparison.

Testing Machine	Load Range	Calibration Centres (MTM ILC - 2001)							Number of Transducers
		A	B	C	D	E	F	G	
Instron 8562	200 N - 10 kN	YES	YES	YES	YES	YES	YES		22
	20 kN - 200 kN	YES		YES	YES	YES	YES	YES	
PMC100	100 kN - 500 kN	YES		YES	YES	YES	YES	YES	17
	100 kn - 1000 kN	YES		YES	YES	YES	YES	YES	
PMC500	50 kN - 500 kN	YES	YES	YES		YES			14
	100 kN - 1000 kN	YES	YES	YES		YES			
	100 kN - 2500 kN	YES			YES	YES	YES	YES	

In 2004 two materials testing machines (MTM) were chosen of 1000kN, 3000kN rated load, located at the University of Ancona.

- Type METROCOM 3 MN (model MI 300, no 6615/75) in compression;
- Type METROCOM 1000 kN (model MI 60, no 6876/77) in compression ;

At the ILC-04 participated 6 SIT accredited Laboratories with 24 reference force transducers.

At the ILCs participated several accredited Laboratories (14) with a big number of Reference Force Transducers (more than 90). For this reason was decided to consider as “reference value”, for each ranges of the different MTMs, the average value of the calibrations carried out by the different laboratories.

With this method, taking for each laboratory the mean value over the three angular positions, it is possible to reduce strongly the effects due the parasitic components . These effects can be further reduced by considering the average value of the results obtained by all the participating Laboratories at the ILC.

The differences against the polynomial regression evaluated from these mean value results could be considered mainly, if not exclusively, due to the calibration capabilities (technical, operational) of each calibration Laboratories with only a limited contribution of the accuracy errors of the different material testing machines.

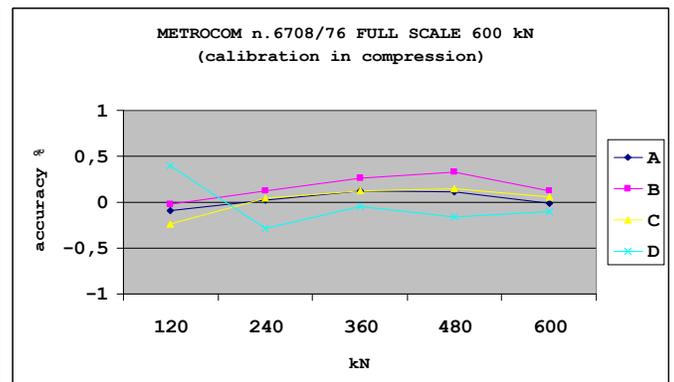
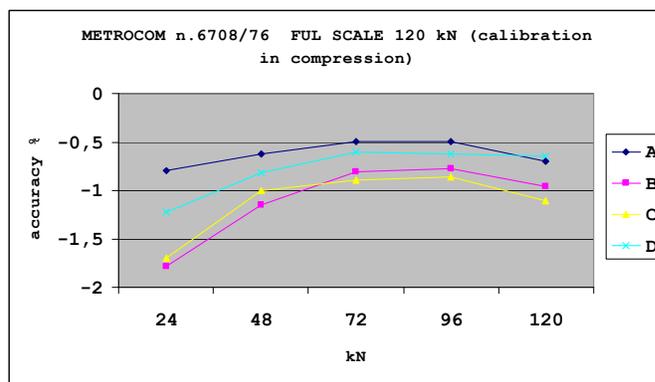
At each laboratory was asked to calibrate the MTMs by using their normal procedure (usually EN ISO 7500-1 and EN 12390/4).

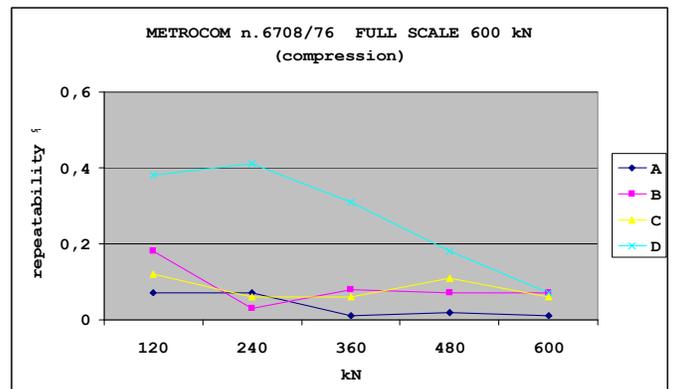
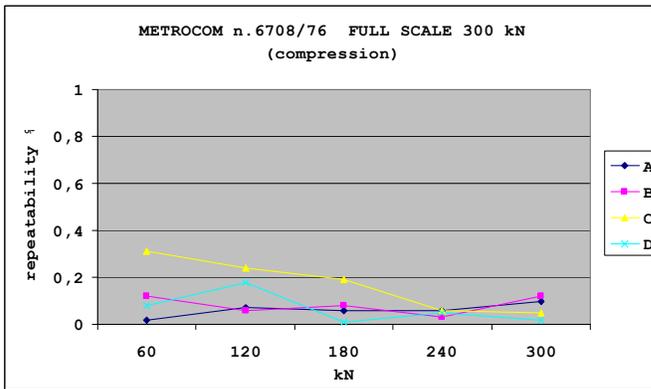
Each Laboratories was not able to carry out the calibration on all the ranges

## Experimental Results and Analysis

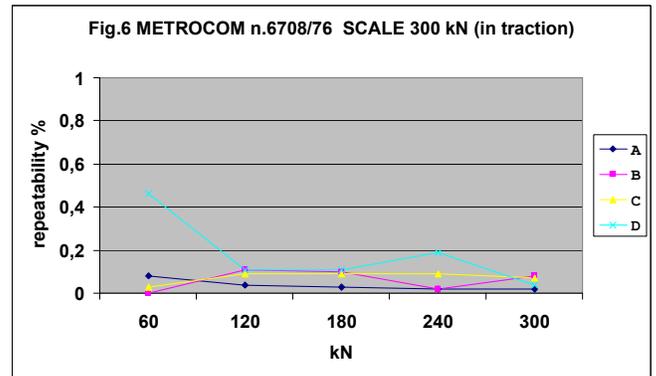
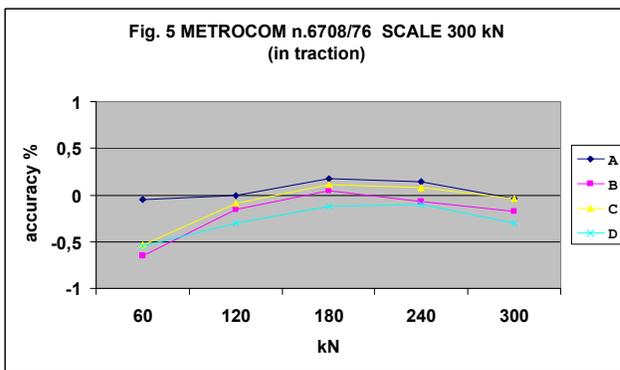
### ILC-99 intercomparison

Figs. 1 to 4 give the accuracy and repeatability determined by the four SIT accredited Laboratories on the METROCOM-600 kN machine in compression (scales: 120 kN, 300 kN e 600 kN).

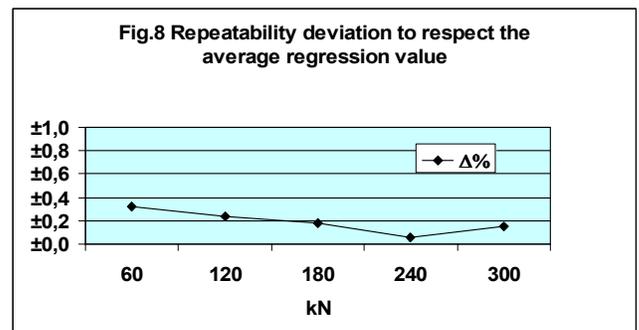
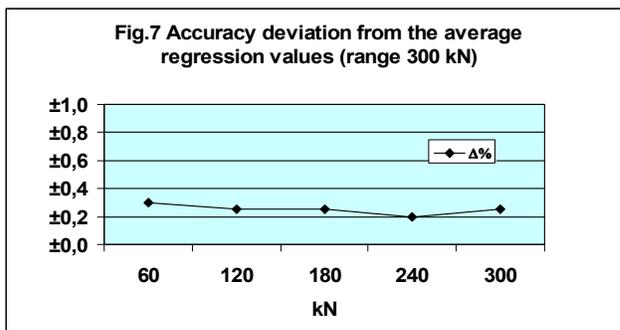




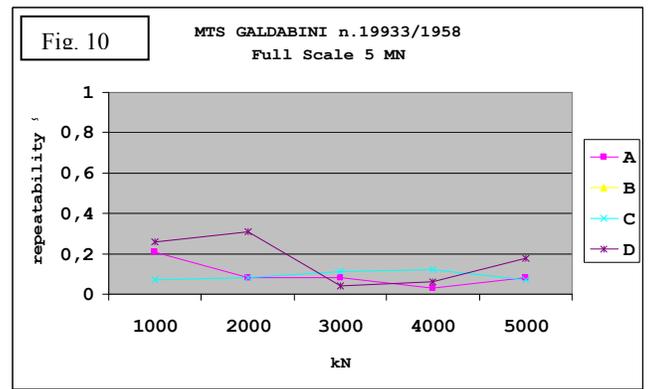
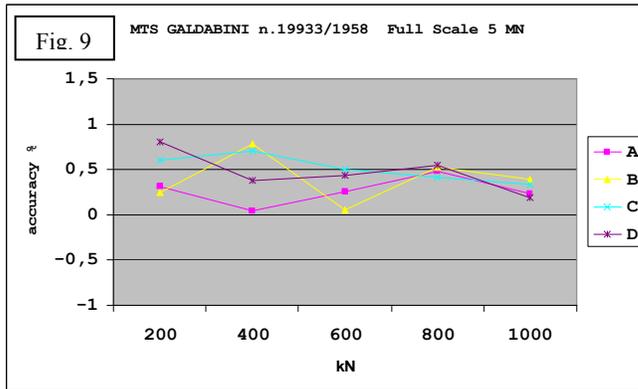
Figs. 5-6 show accuracy and repeatability as determined in traction



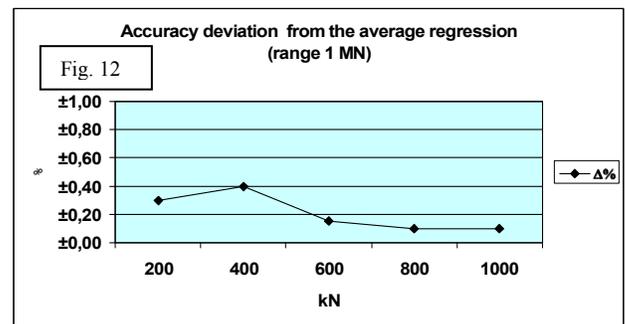
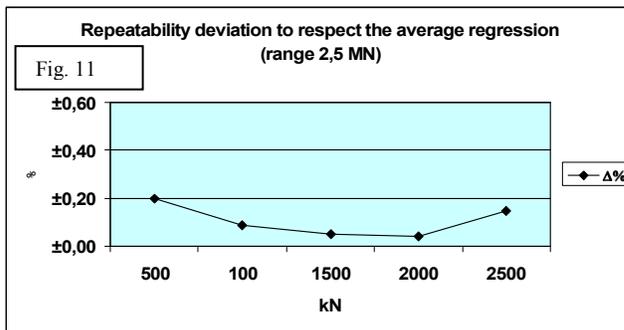
In Figs. 7-8 the total accuracy and repeatability deviation of all the Laboratories to respect the average regression values for each calibration points are reported.



Figs. 9-10 give an example of the accuracy and repeatability measured by the four SIT accredited Laboratories on the Galdabini-5 MN machine.



In Figs. 11-12 the total accuracy and repeatability deviation of all the Laboratories to respect the average regression values on the Galdabini-5 MN machine are reported.



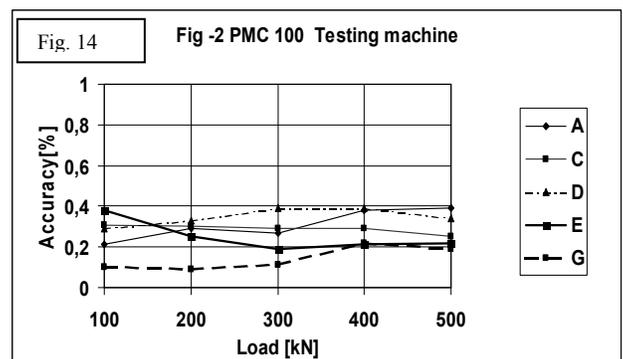
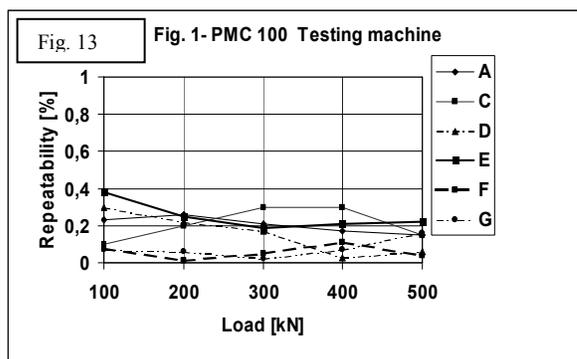
The agreement of the results obtained by the SIT accredited Laboratories could be considered very good for the different scales of METROCOM-600 kN and Galdabini-5MN machines. It is necessary to remember that the accuracy (q), as defined in the ISO 7500/1 standard, is an intrinsic property of the MTM.

For this reason the deviations from the regression equations were evaluated (Figs. 7-8 and 11-12)

### ILC-01 intercomparison

Fig. 13 shows the repeatability given by the participating Laboratories (A; C; D; E; F; G) for the PMC-100 material testing machine (range 500 kN).

Fig. 14 gives the accuracy as determined on the same testing machine in compression.



Figs. 15 and 16 give the accuracy results as determined by the Laboratories A, D, E, F and G on the PMC-500, range 2500 kN, for different piston positions (10mm, 40 mm). In fact, “for hydraulic machines, where the hydraulic pressure at the actuator is used to measure the test force, the influence of a difference in position of the piston shall be verified (ISO, point 6.4.7)”.

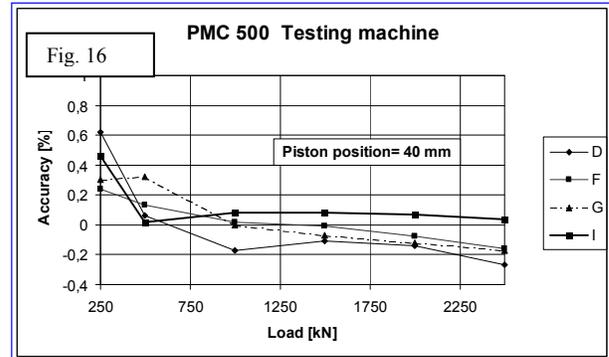
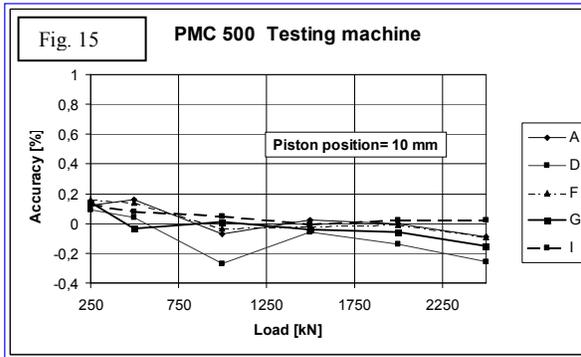
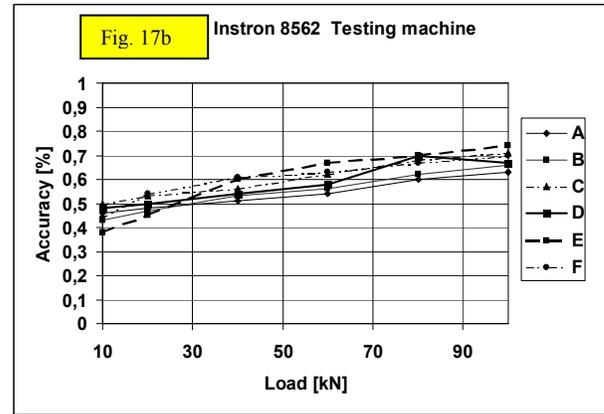
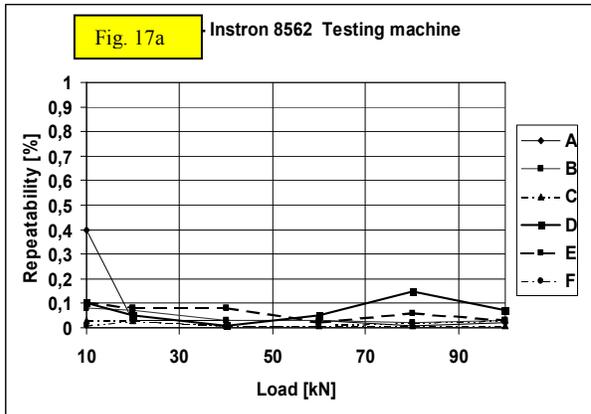
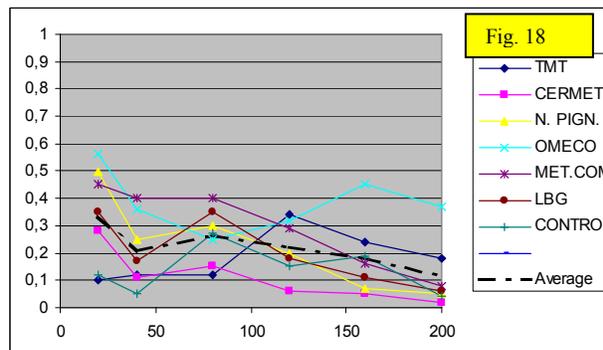


Fig. 17 give the calibration results in tension (repeatability and accuracy) for the Instron material testing machine from 10 kN to 100 kN.



### ILC-04 intercomparison

In 2004 two materials testing machines (MTM) were chosen of 1000kN, 3000kN rated load, located at the University of Ancona. Fig. 18 gives, as an example of this exercise, the accuracy [%] determined in compression by the 7 different accredited Laboratories on the METROCOM 1000 kN (model MI 60, no 6876/77)



All the diagrams give the measurement results without reversibility because the reversibility, as outlined by other author [5], depends more from testing machine than from the reference transducers.

The standard ISO 7000/1 gives in fact the possibility to carry out the calibration of static uniaxial material testing machines with or without reversibility but, according point 6.4.8 of the ISO Standard, the relative reversibility error is only determined when required.

The results of the calibration of the material testing machine in tension show, as can be expected, the lowest deviation between the different accredited Laboratories. The parasitic components are lower and the force transmission conditions for the different Laboratories are more uniform for the test in tension.

The results can be evaluated using the normalized error  $En$  calculated according to ISO Guide 43:

$$En = \frac{X_{LAB} - X_0}{\sqrt{U^2_{LAB} + U^2_0}} \quad (1)$$

Where:

$X_{LAB}$  = the calibration result given by the Laboratories

$X_0$  = the reference value

$U_{LAB}$  = the accredited uncertainty reported by the Laboratories

$U_0$  = the uncertainty of the reference value.

All the Laboratories show an  $En < 1$  referred at the accredited uncertainty (usually related to Class 1)

## Conclusion

At the ILCs participated 14 accredited Laboratories with 90 Reference Force Transducers. For this reason was taken as “reference value”, for each ranges of the different uniaxial material testing machines, the average value of the calibrations carried out by the Laboratories. The differences against the polynomial regression evaluated from these mean value results could be considered mainly, if not exclusively, due to the calibration capabilities (technical, operational) of each SIT accredited Laboratories with only a limited contribution of the accuracy errors of the different material testing machines, but not for the stability.

The results given by all the SIT accredited Laboratories are in good agreement as regards repeatability, accuracy (usually inside  $\pm 0,2\%$ ) as well the classification (class 1 in compression and class 1 in tension).

## References

[1] C. Ferrero, S. D’Emilio, Accreditation of Calibration, Testing Laboratories and Certification Bodies in Italy, SINO-ITALIAN SEMINAR ON METROLOGY, Beijing, (2001)

- [2] C. Ferrero, The EA Mechanical Measurement Activities: Accreditation of Calibration and Testing Laboratories and the Force and Torque Dissemination in Italy, International Symposium METROLOGY 2002, Cuba, (2002), 130-160
- [3] C. Ferrero, Report on the Activities of the EA-Expert Group "Mechanical Measurements", EA/LC, Madrid, (2001)
- [4] C. Ferrero, C. Marinari, Calibration of material testing machine intercomparison, IMEKO TC3/TC5/TC20, Celle, (2002), 77-82
- [5] A. Pusa, Nordic Intercomparison of Calibration of the Material Testing Machines: Report of the Force Calibration, XVII IMEKO TC3, Istanbul, Turkey, (2001), 171-178

**Corresponding author:**

Carlo Ferrero, INRIM, Strada delle Cacce, 73; Torino -10135 Italy. Phone int.: +39 011 3919752; Fax int.: +39 011 3919 503. E-mail: [c.ferrero@inrim.it](mailto:c.ferrero@inrim.it)

Luciano Bianchi, SIT-INRIM, Strada delle Cacce, 73; Torino -10135 Italy. Phone int.: +39 011 3919915; Fax int.: +39 11 3919 372. E-mail: [l.bianchi@sit-italia.it](mailto:l.bianchi@sit-italia.it)