



STIPA – The golden mean between full STI and RASTI

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Norsonic AS



STI – speech transmission index

1971

TNO-Human Factors, The Netherlands

Tammo Houtgast and Herman.J.M. Steeneken:

Evaluation of Speech Transmission Channels by
using Artificial Signals

(Acustica)



IEC 60268-16

During the last 30 years methods has been refined and diversified for various applications.

2003-05

Third revision:

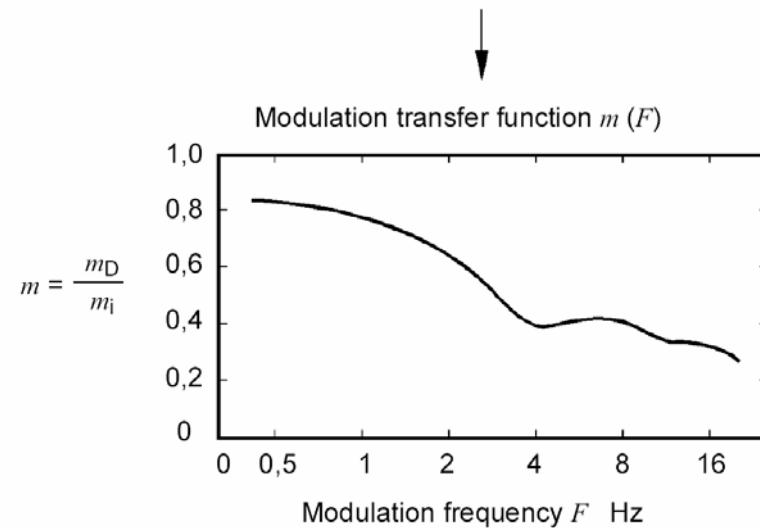
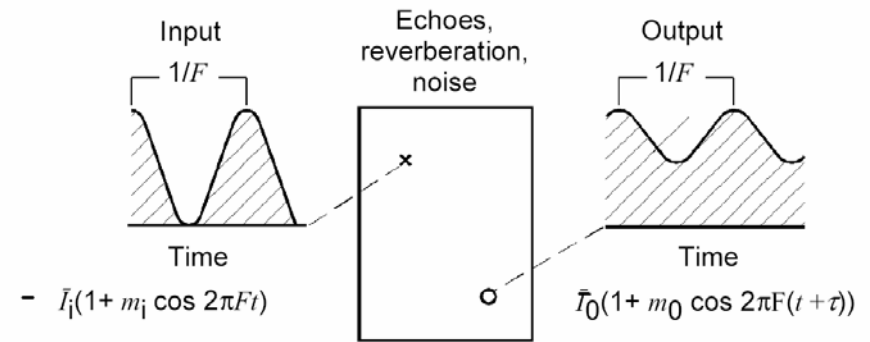
IEC 60268-16:

Sound system equipment - Part 16: Objective rating of speech intelligibility by speech transmission index.



Speech intelligibility

– based on the slow modulation of the strength of the sound pressure signal acting as a carrier.





Carrier:

7 octave bands:
125 Hz – 8 kHz,
gaussian noise

Modulation:

14 Frequencies:
0,63 Hz to 12,5 Hz

Combinations: 98

		Carrier frequency [Hz]						
		125	250	500	1k	2k	4k	8k
Modulation frequency [Hz]	0,63							
	0,8							
	1							
	1,25							
	1,6							
	2							
	2,5							
	3,15							
	4							
	5							
	6,3							
	8							
	10							
	12,5							



STI based on:
The weighted average of
the different modulation
indexes

- Considers masking effects
- Threshold of hearing

		Carrier frequency [Hz]						
		125	250	500	1k	2k	4k	8k
Modulation frequency [Hz]	0,63							
	0,8							
	1							
	1,25							
	1,6							
	2							
	2,5							
	3,15							
	4							
	5							
	6,3							
	8							
	10							
12,5								



- Noise signal with a high crest-factor
- Spectral distribution similar to the long-term speech spectrum
- Modulation frequency is selected one by one.
- The measurement is performed in a sequence.
- If each of the 98 combinations is measured in 10 seconds, Total measurement time: 16 minutes.
- Limits the applicability of the full STI-method.



- Non-linearities

harmonic distortion

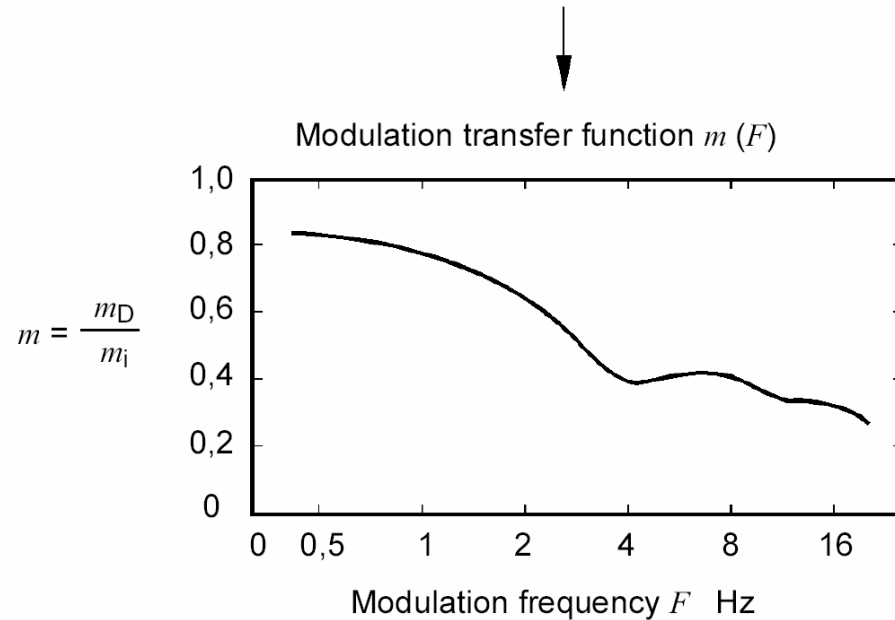
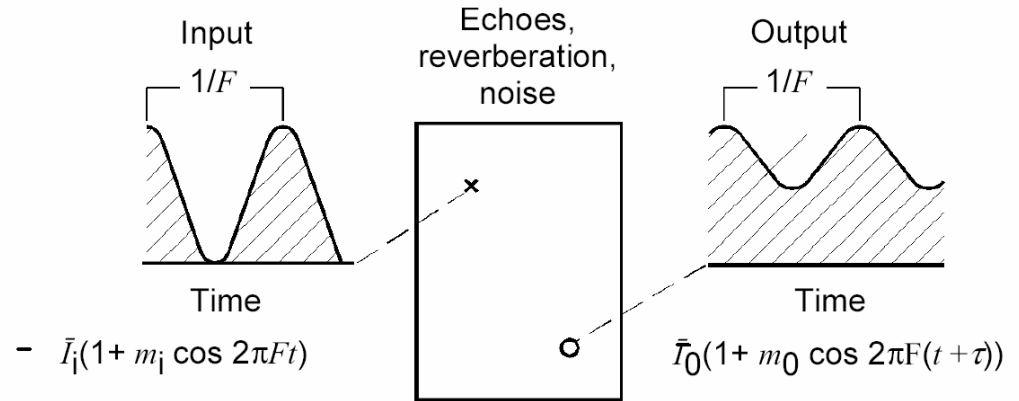
intermodulation

~~Frequency shift~~

- Time distortion

Reverberation and echo

- Noise





STI - Linear systems

Reduction in measurement time :

- Measure the impulse response for each octave
 - Direct, MLS, Swept-sine,
- Measure the noise
- Calculate the complex modulation transfer function and correct for the noise

$$m(\omega) = \frac{\int_0^{\infty} h^2(t) e^{-j\omega t} dt}{\int_0^{\infty} h^2(t) dt} \cdot \frac{p_s^2}{p_s^2 + p_n^2}$$

- Calculate STI from m



STI - Linear systems – Exponential decay

Reduction of measurement time :

- Measure the reverberation time and signal/noise ratio for each octave

$$m(F) = \frac{1}{\sqrt{1 + \left(2\pi F \frac{T}{13,8}\right)^2}} \cdot \frac{1}{1 + 10^{(-S/N)/10}}$$

- Calculate STI from m



STI - Linear systems – Exponential decay

Excel sheet for STI-calculation

Enter values in the green fields

	Trev [s]	Ls [dB]	Ln [dB]
125 Hz	0,7	65	45
250 Hz	0,6	69	43
500 Hz	0,5	63	41
1 kHz	0,5	57	39
2 kHz	0,6	50	37
4 kHz	0,4	47	35
8 kHz	0,3	41	33

STI_r = 0,69

Intelligibility: Good



RASTI

RASTI

Room Acoustic Speech Transmission Index
developed at TNO in 1979

- Measurement time 10 – 15 s
- Two octaves
- 4 + 5 modulation frequencies

		Carrier frequency [Hz]						
		125	250	500	1k	2k	4k	8k
Modulation frequency [Hz]	0,63					■		
	0,8					■		
	1			■				
	1,25					■		
	1,6					■		
	2			■				
	2,5					■		
	3,15					■		
	4			■				
	5					■		
	6,3					■		
	8			■				
	10					■		
	12,5					■		



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STI – Public Address

- Measurement time 10 – 15 s
- All octaves
- Two modulation frequencies for each octave

		Carrier frequency [Hz]						
		125	250	500	1k	2k	4k	8k
Modulation frequency [Hz]	0,63			■				
	0,8						■	
	1	■	■					
	1,25					■		
	1,6							
	2				■			
	2,5							■
	3,15			■				
	4						■	
	5	■	■					
	6,3					■		
	8							
	10				■			
	12,5							■



The STIPA-method may be implemented in a standard sound level meter.

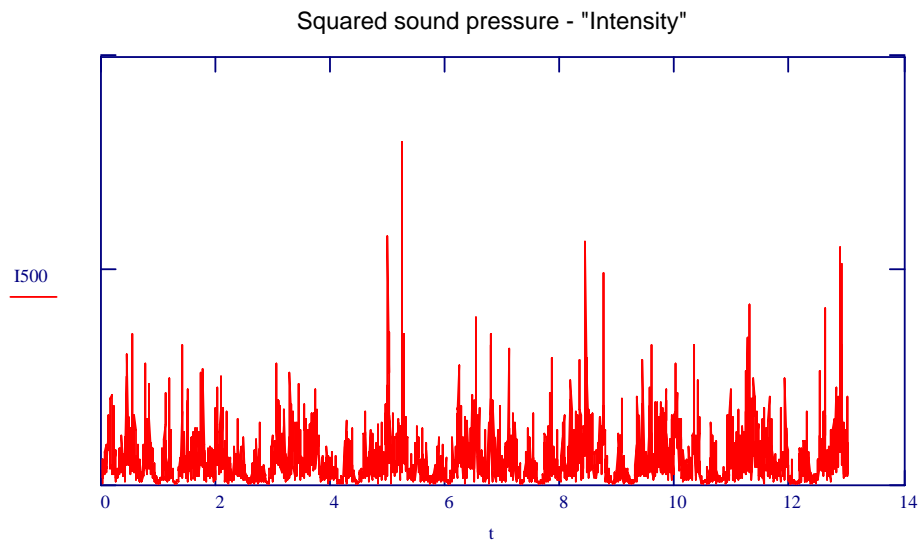
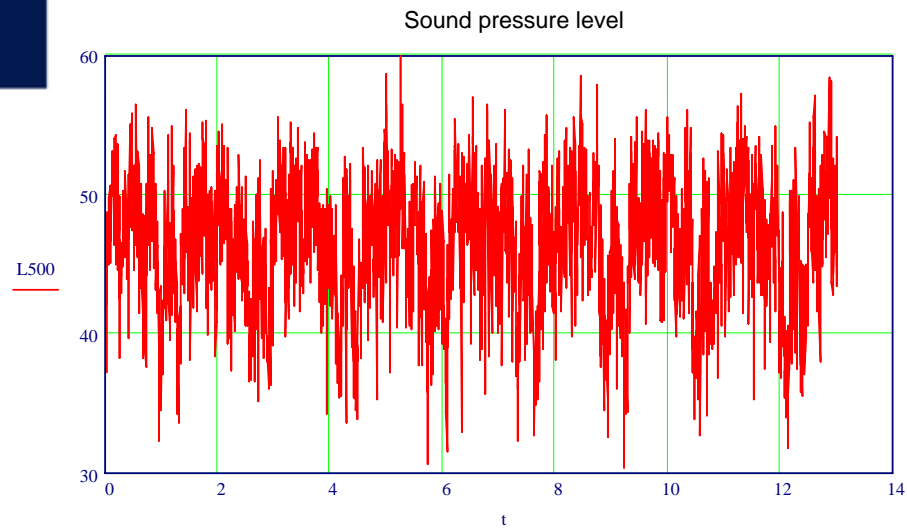
In the sound level meter Norsonic Nor118 the method is implemented as a program option in the instrument software

Excitation is done by playing a CD

Measurement time: 13 seconds



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Typical level- and "intensity-"
signal for 500 Hz band



Noise may be added if not a part of the measurement



Measured modulation

Measured level

$$mc_{k,f} = m_{k,f} \frac{I_k}{I_k + Irs_k + Ino_k + Iam_k}$$

Threshold of hearing

Masking

Background noise

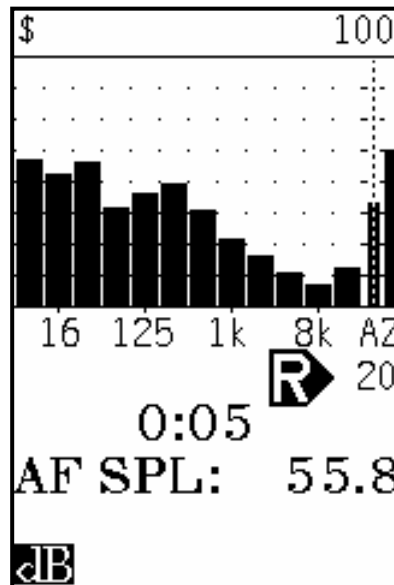


Typical set up for measurement of STIPA





The octave bands spectrum is displayed during the measurement.





STIPA

The rating is displayed after the measurement and may be stored with the octave spectrum.



```
$
STI = 0.62
  "Good"
CIS = 0.79
LA = 53.3
NCorr: OFF
dB
```

```
$
0:13
%oct   Lea:
125Hz  61.6
250Hz  59.1
500Hz  50.5
1.0kHz 41.9
2.0kHz 33.5
4.0kHz 25.4
8.0kHz 23.4
16.0kHz 30.0
A-netw. 53.3
dB
```



STIPA

The measured modulation indices may be displayed.



\$	
1/4-oct	m
250Hz	
1	0.96
5	0.79
500Hz	
0.63	0.89
3.15	0.93
1.0k Hz	
2	0.85
10	0.81

dB

\$	
1/4-oct	m
2.0k Hz	
1.25	0.82
6.3	0.72
4.0k Hz	
0.8	0.36
4	0.36
8.0k Hz	
2.5	0.10
12.5	0.06

dB



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The values may be corrected for a virtual background noise (What if?).

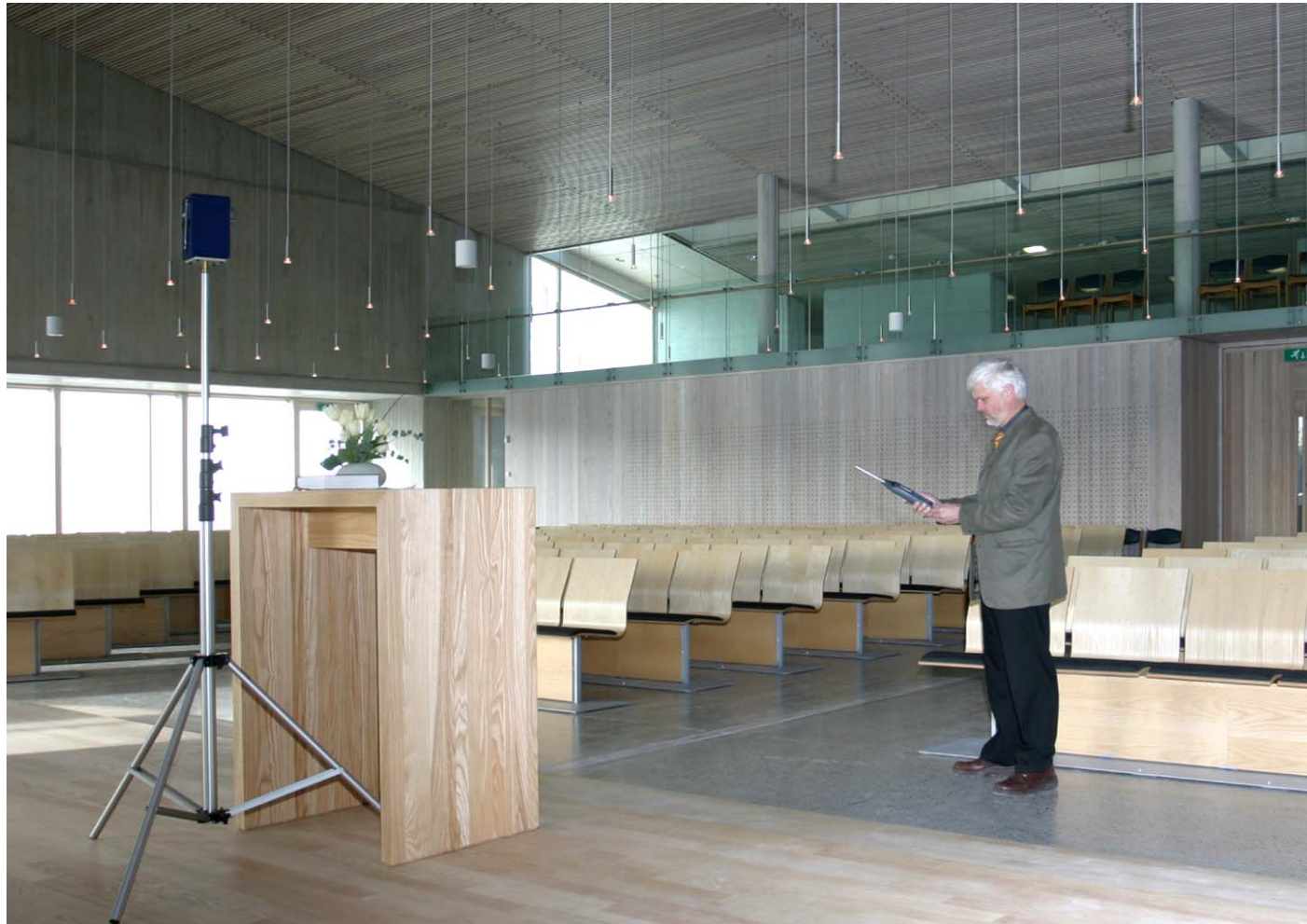


```
$
STI = 0.62
  "Good"
CIS = 0.79
LA = 53.3
N Corr: ON
STI = 0.38
  "Poor"
CIS = 0.58
dB
```

```
$ Noise edit
1/2-oct   Leq
125Hz    45.0
250Hz    51.0
500Hz    52.0
1.0 kHz  42.0
2.0 kHz  35.0
4.0 kHz  27.0
8.0 kHz  25.0
dB      #
```



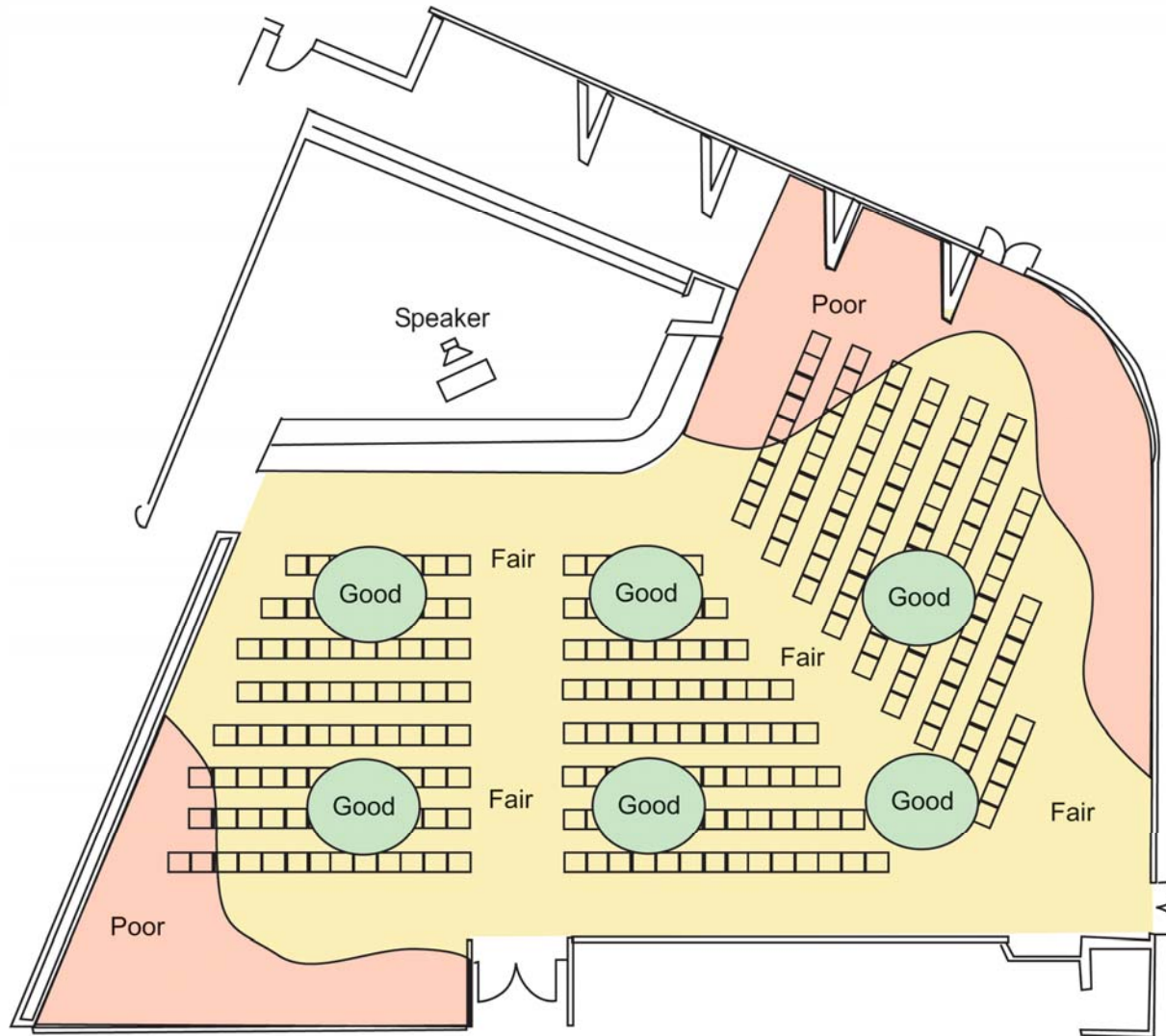
STIPA



STIPA – The golden mean between full STI and RASTI #22



STIPA



Conclusion



- Implementation of the STIPA-measurement mode in an ordinary sound level meter allows an easy and fast measurement of speech intelligibility.
- Allows measurement with real noise and distortions.
- Synthetic background noise may be added.
- "What if" situations may be investigated.
- STIPA gives in most cases more reliable results than RASTI.

