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Health Monitoring of Overhead Power Transmission Line:

User Needs

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Summary

1. What the User Needs NOT?

New York - August 14, 2003
Black-Out in USA, initiated by increased conductor sag due to overheat

Concerns

- Ageing
- Increasing Power Loads
- Deregulation in Power Transmission

Impacts

- **Wind**
- **Corrosion**
- **Contamination**

What *kind of monitoring* user needs?

- ✓Real-time & Permanent
- ✓Nondestructive & Hotline Mounted
- ✓Predictive, Secure, Controllable etc.

Why Real-time & Permanent?

> Maintenance

> Optimal Power Delivery

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Wind-induced motion

Ageing

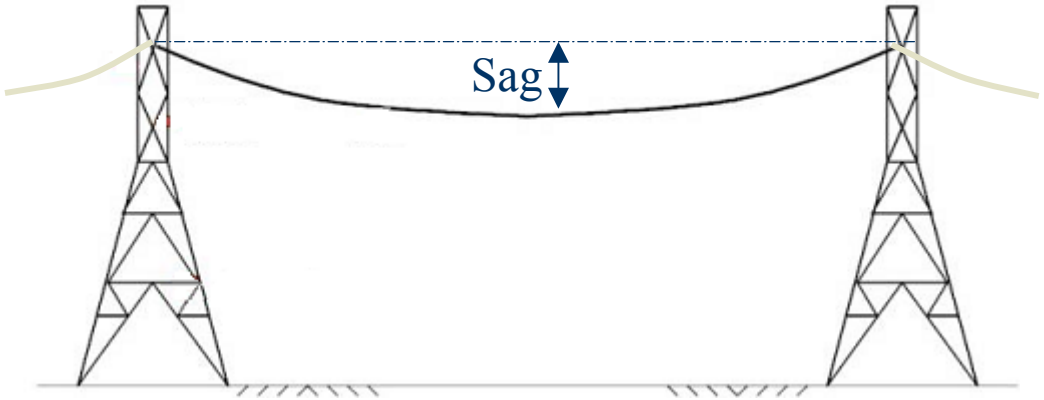
Prevent hazards…

Why Real-time & Permanent?

> Maintenance

> Optimal Power Delivery

Sag and/or Temperature Monitoring



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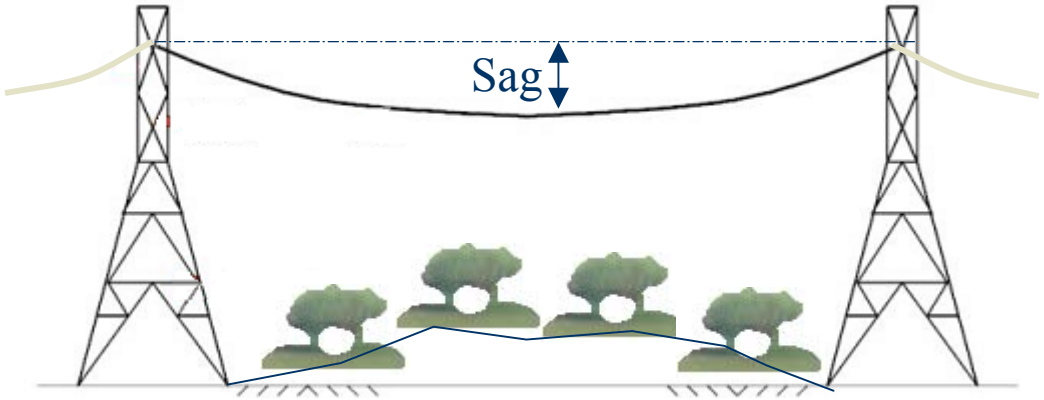

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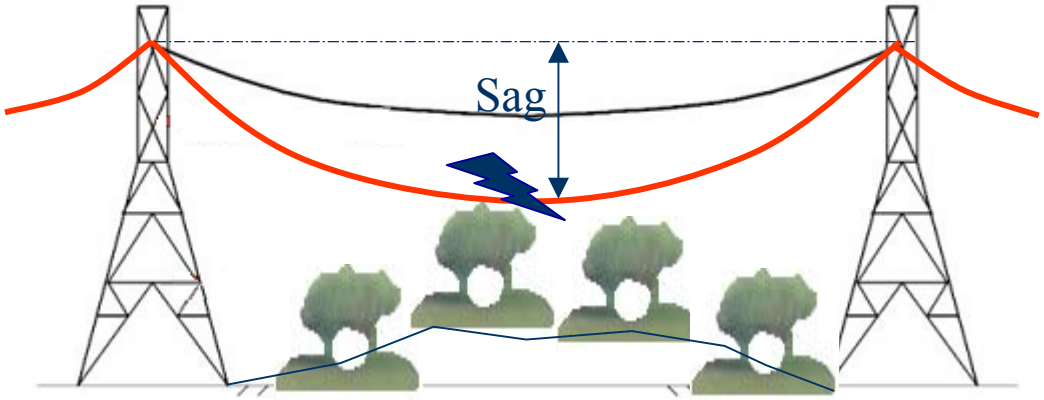
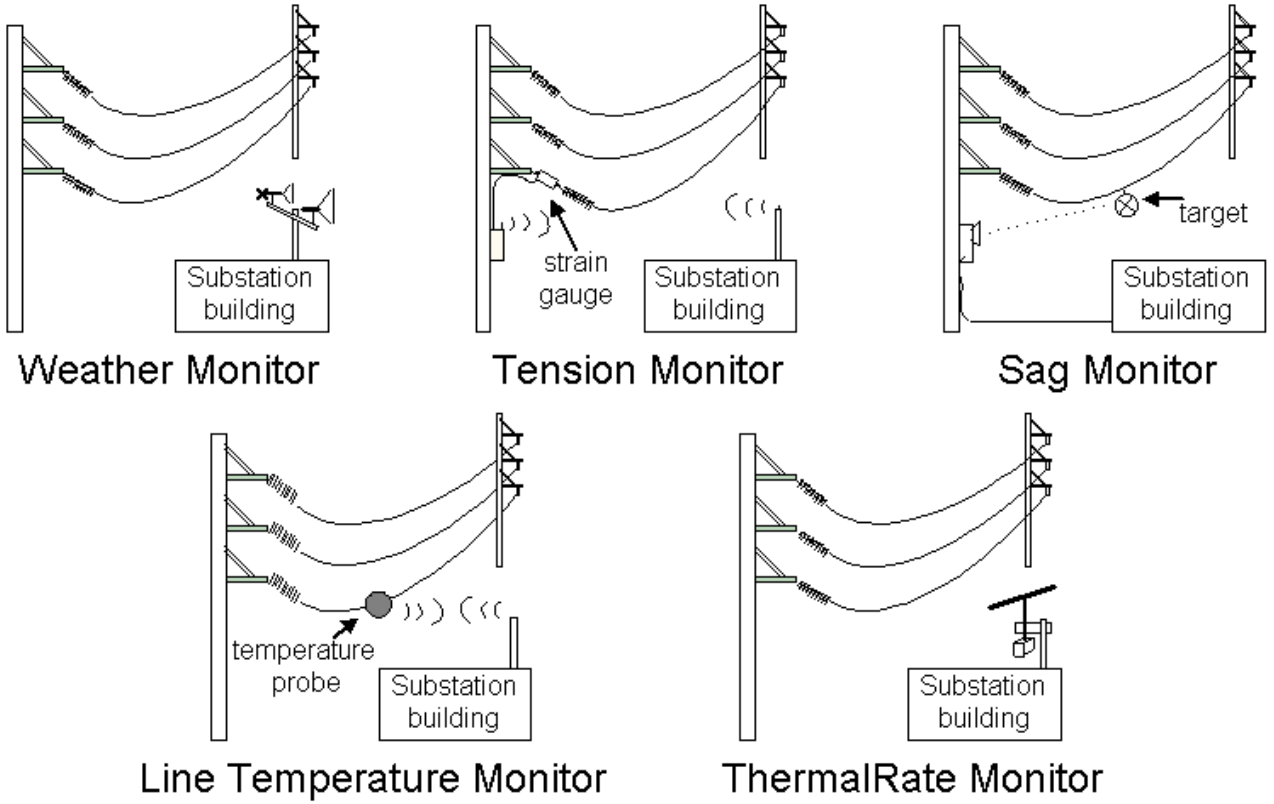
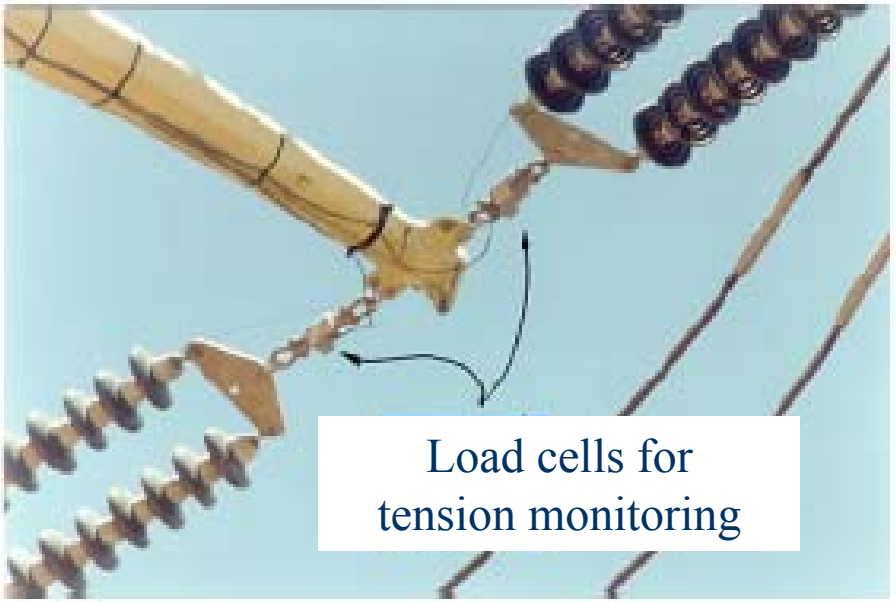


2. Sag monitoring methods



Tension monitoring

CAT monitor



SDG&E CAT monitor installed on a 230 kV anchor tower.

Direct radio communications are established with the ground station (GS).

GS dumps the data to the post via telephone line.

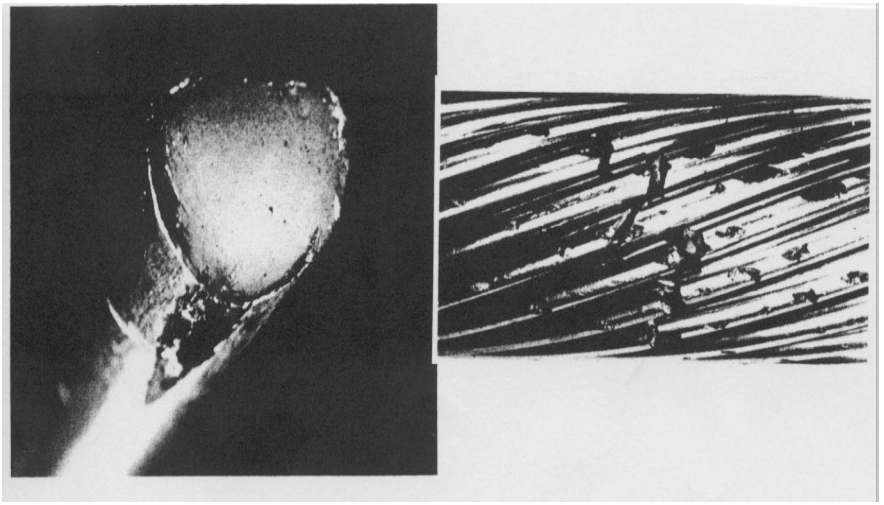
Sag monitoring

Sagometer (EDM International, Inc.)

3.OHL Sensible elements

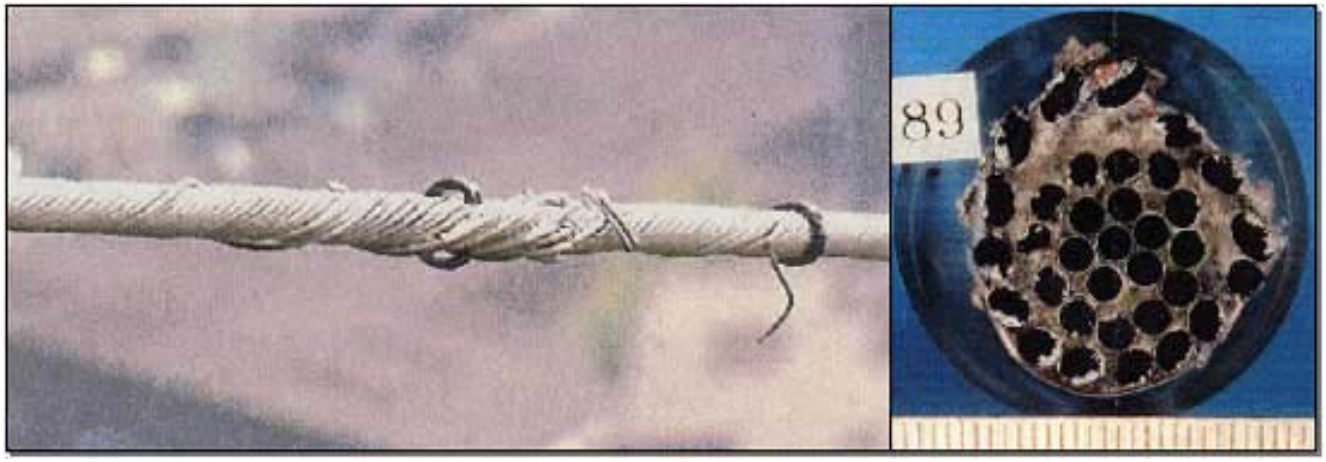
1. Conductors
2. Fittings (spacers, insulator chains, …)
3. Towers

Conductor damages



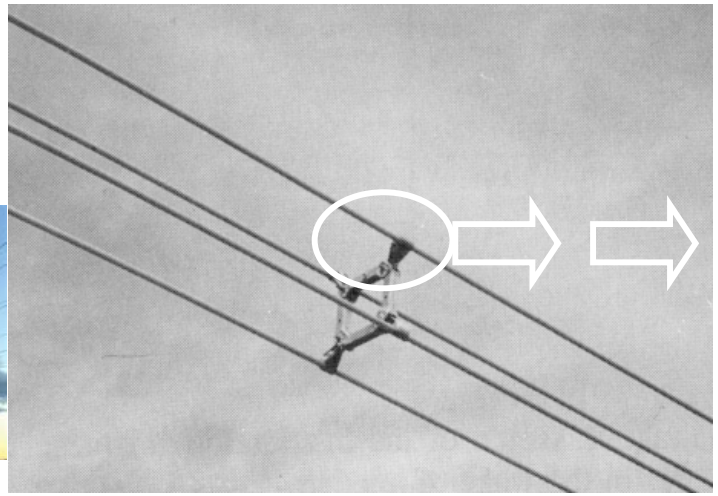
Fretting fatigue of second layer of strand (left) or surface failure (right)

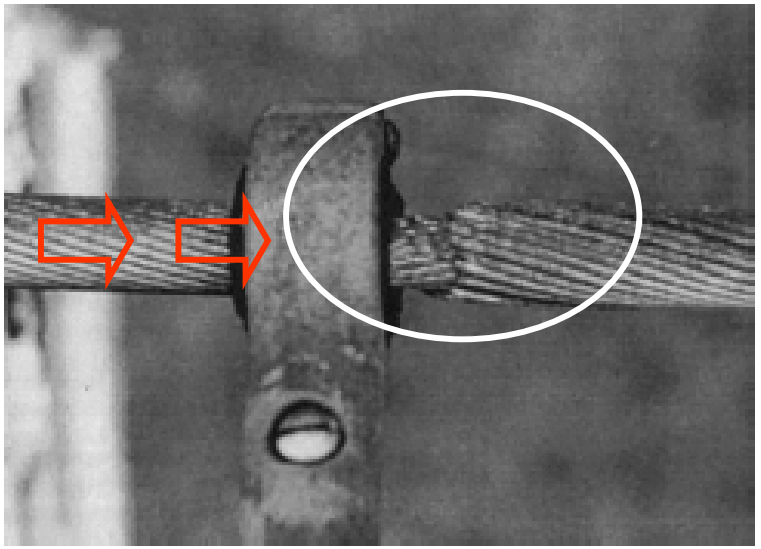
Conductor damages



Strand breaking due to corrosion

Conductor damages





Conductor damages

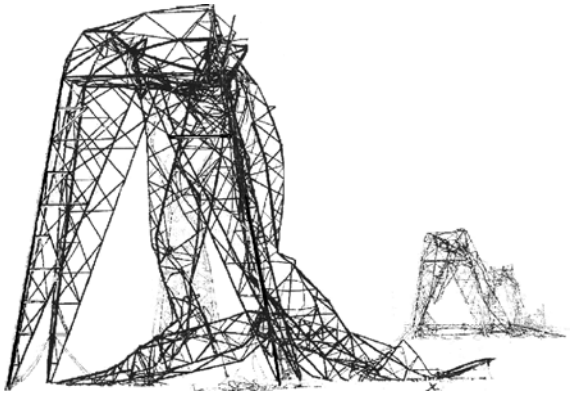
Aeolian vibration-induced damages of conductor - contact with suspension saddle

Conductor damages

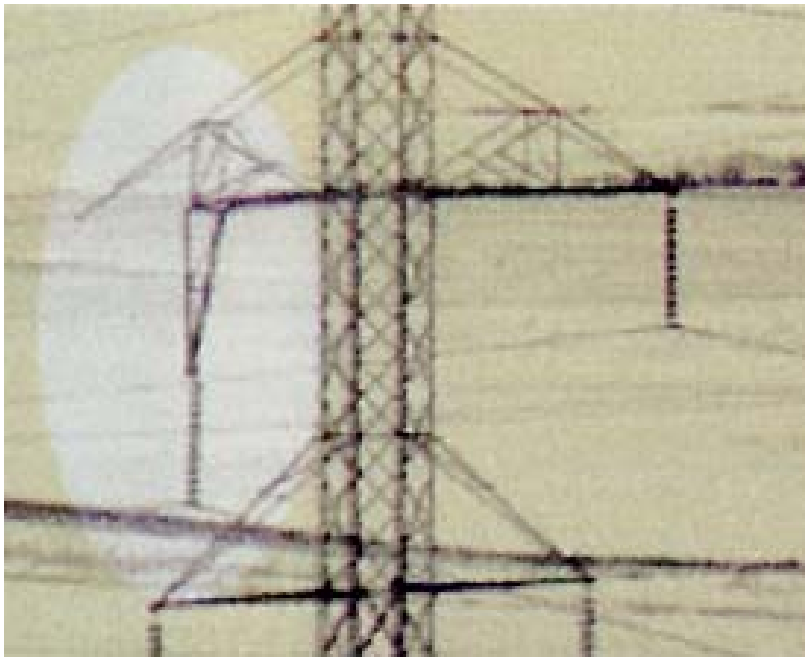
Aeolian vibration-induced damages of conductor - contact with Aircraft Warning Marker

Tower Damages

Galloping

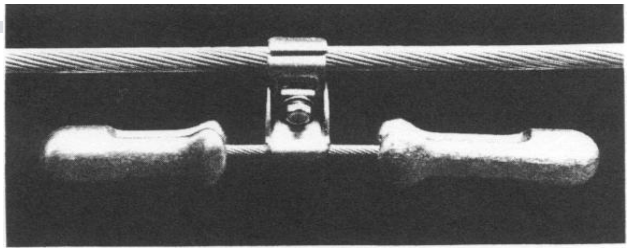


Aeolian vibration

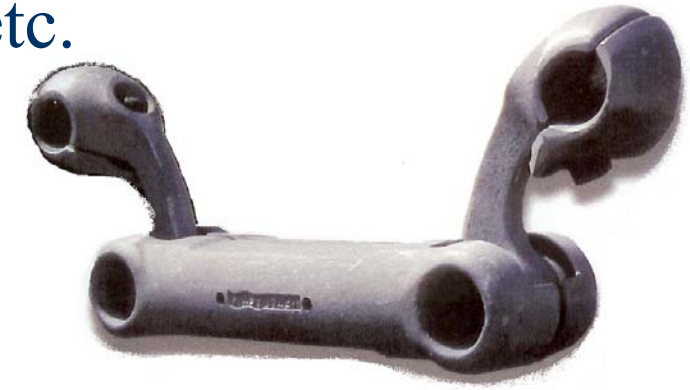


Other:

- Spacers, spacer dampers
- Vibration dampers
- Insulators
- Aircraft warning markers
- etc.



Stockbridge damper



Twin bundle spacer damper

Insulator chain

4. Damage Diagnostic Methods

- Corona Discharge-based (CM)
- Electro-magnetic Acoustic (EMAT)
- Space potential probes (EPRI project)

Damage Diagnostic

EMAT (Electro Magnetic Acoustic Transducer)

Colorado School of Mines, U.S.A.

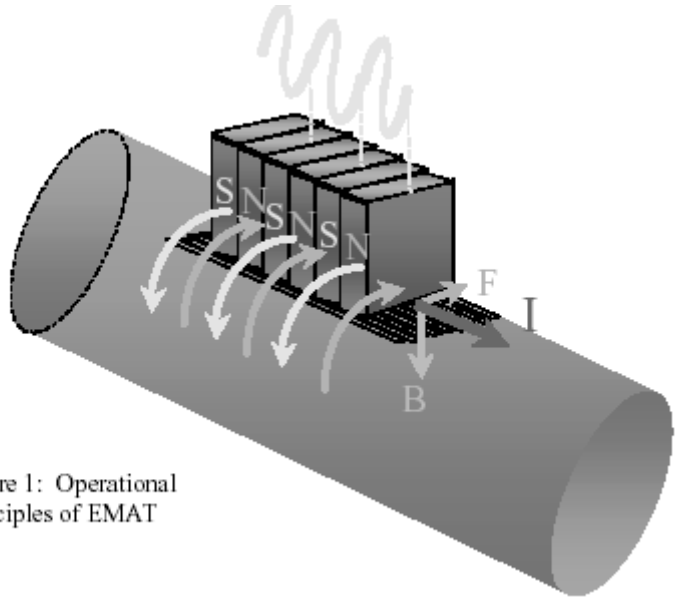


Figure 1: Operational Principles of EMAT

EMAT
(Electro Magnetic Acoustic Transducer)

+ Can be used on live (hot) conductors

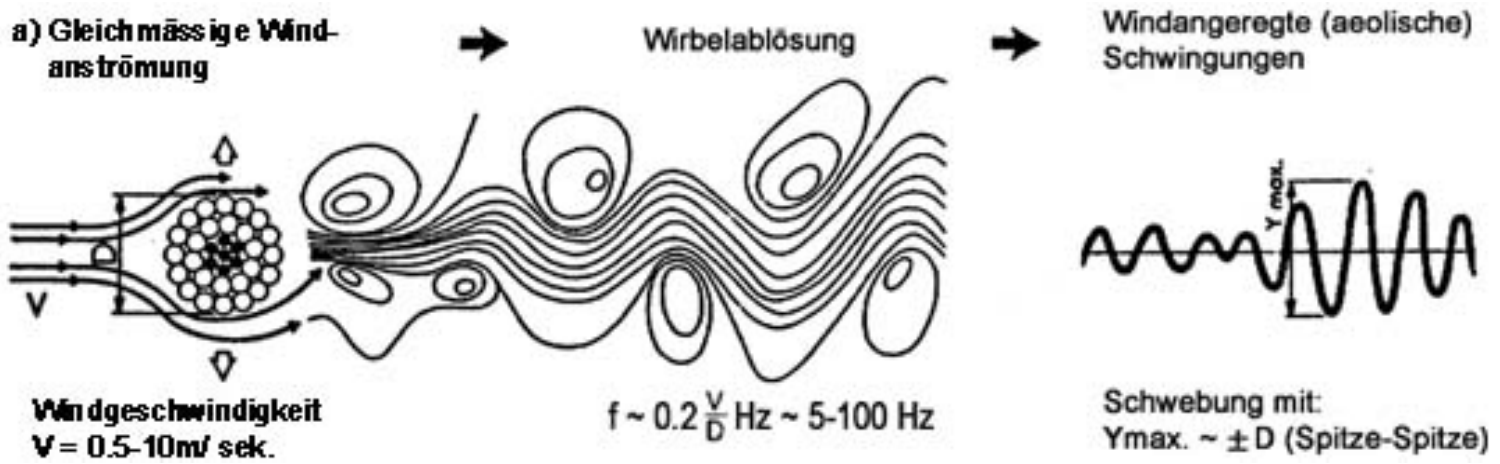
+ Allows detecting minor defects

- Time-limited

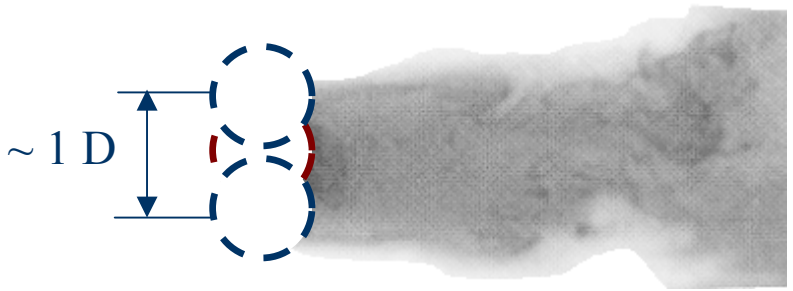
5. Diagnose the Wind - Induced Vibrations

- Unavoidable
  - ✓ Turbulence-induced
- Necessary to minimize:
  - ✓ Galloping
  - ✓ Wake-induced vibrations
  - ✓ Aeolian vibrations

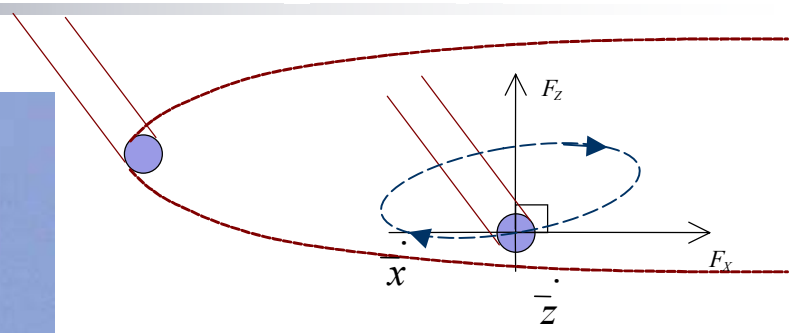
Aeolian Vibration

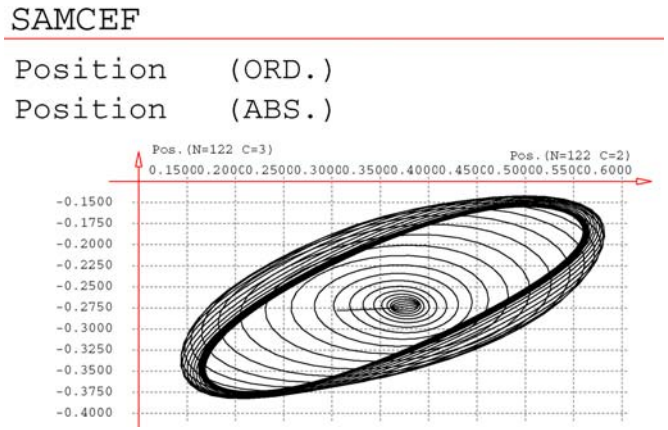


Oscillation Amplitude

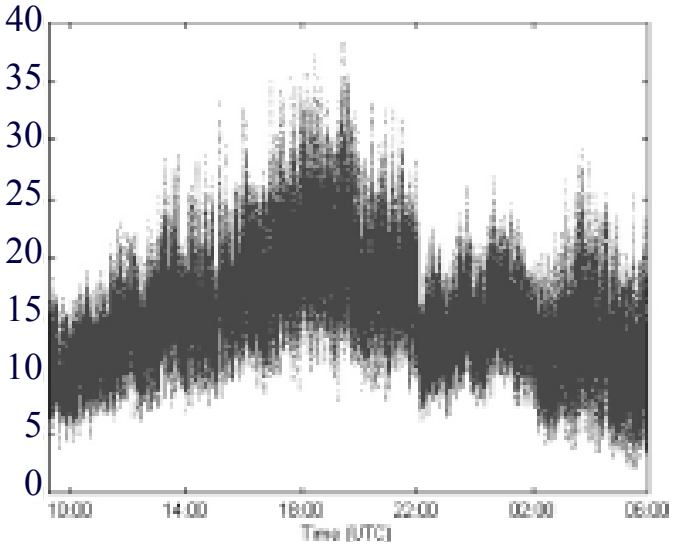


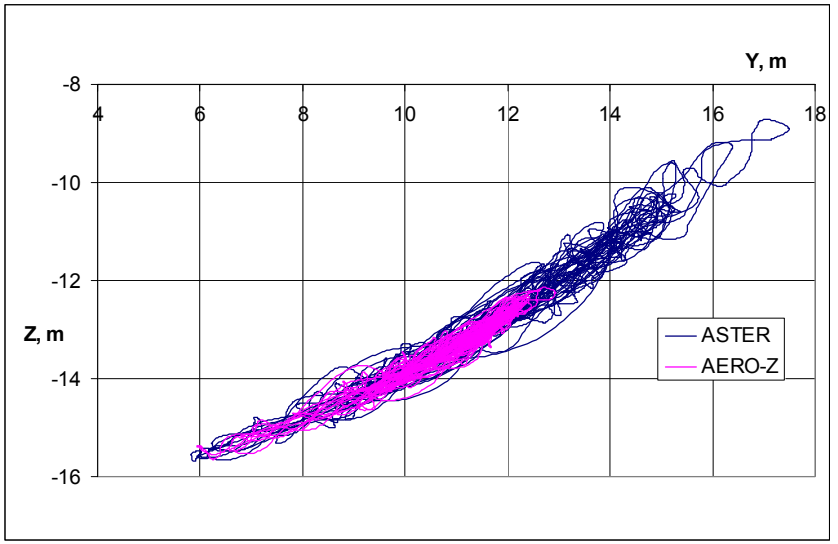
Wake-Induced Vibration

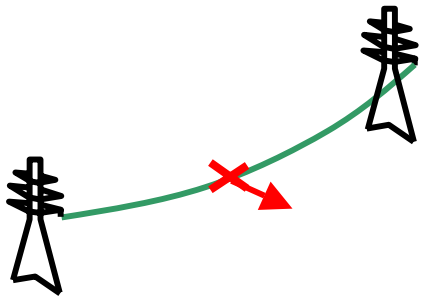




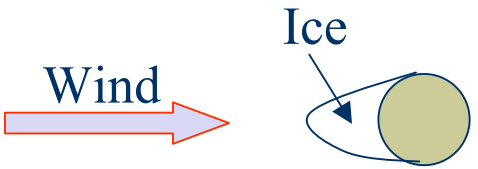
Turbulence-Induced Buffeting



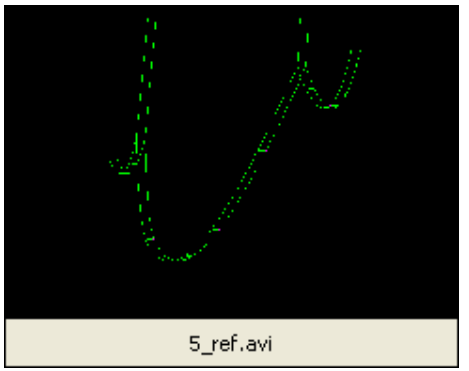




Galloping

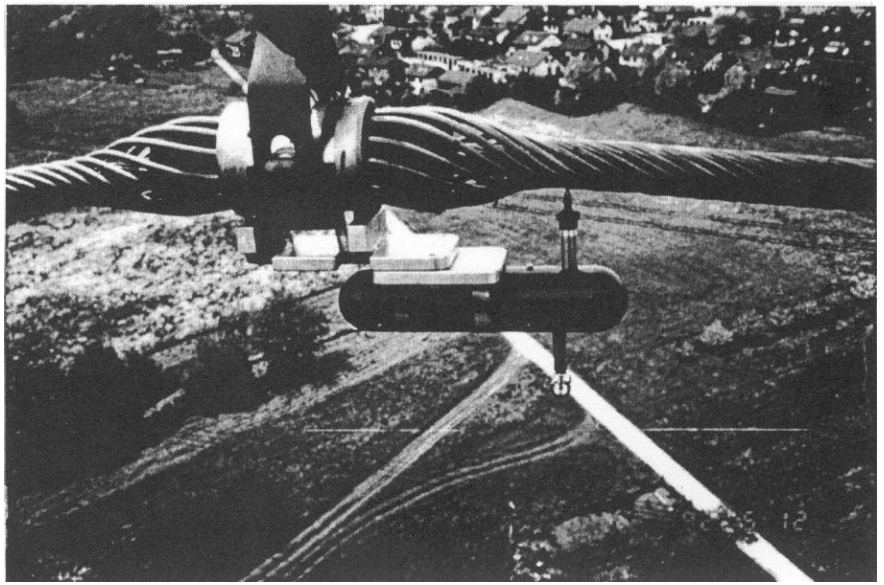


$$\frac{\partial C_L}{\partial y} + C_D < 0$$



6. Vibration Measurement

Existing measuring devices



SEFAG vibration recorder (Conductor diameter: about 0.03 m)

Vibration Measurement

Heavy weight (more than 5 kg)

- > conductor fatigue

High cost (~10000 €)

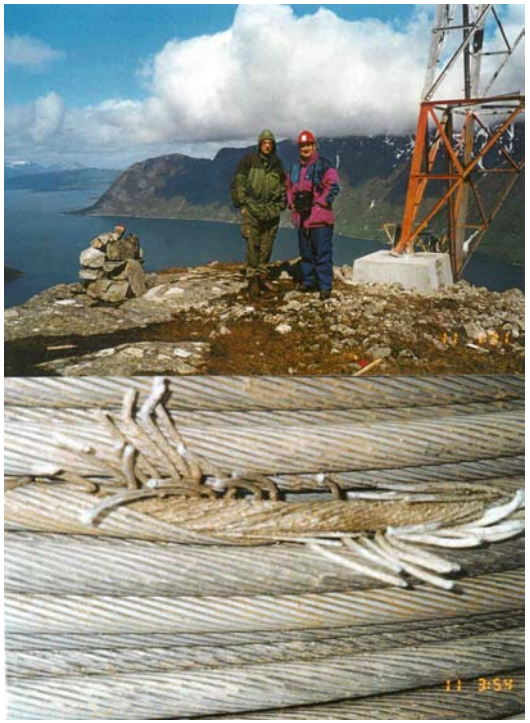
Limited Autonomy

- Impossible to detect reliably the large amplitude at mid-span
- Higher frequencies cannot be recorded.

7. Conclusions?

- Health Monitoring of Overhead Transmission Lines is of increasing importance
- Tension & sag monitoring is more elaborated but still a competitive field
- OHL conductor vibration monitoring devices have limitations (cost, monitoring period)
- Diagnostic of damages and hazards in OHL needs both « Artificial Intelligence » and hardware tools.

The most challenging studies…



…are the worst garnished!

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