Guiding Noise and Vibration Design along General TRIZ Process by Misunderstanding Knowledge Base

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Early Stages of Typical Product Development Process

Product Planning

Identifying Needs for Improvement

Product Specification

Concept Generation

Concept Testing & Selection

Industrial Design and Design for Manufacturing

Opportunities and Risks of Applying TRIZ in Each Step

1. Product Planning stage

Opportunities:

Technical trend analysis

Resource analysis

Benefits: Technical road-map for efficient development of product series

Risks: Unrealistic expectation to new technology

Opportunities and Risks of Applying TRIZ in Each Step (2)

2. Needs Identification stage

Opportunities: Problem definition by abstraction and generalization

Benefits: Development effort concentration

Risks:
Choosing unsuitable analysis methods
Wrong interpretation of analysis results

Opportunities and Risks of Applying TRIZ in Each Step (3)

3. Specification Identification stage

Opportunities:

- Usage of contradiction matrix
- Resource identification
- Problems generalization

Benefits: Can focus development effort

Risks:

- Wrong selection of contradicting factors
- Wrong selection of specifications related to human factors

Opportunities and Risks of Applying TRIZ in Each Step (4)

4. Concept Generation stage

Opportunities:

Usage of contradiction matrix and Inventive Principles

Resource identification

Benefits: Generation of Ideal Final Result

Risks:

Selection of unusable technology

Opportunities and Risks of Applying TRIZ in Each Step (5)

5. Concept Testing & Selection stage

Opportunities:

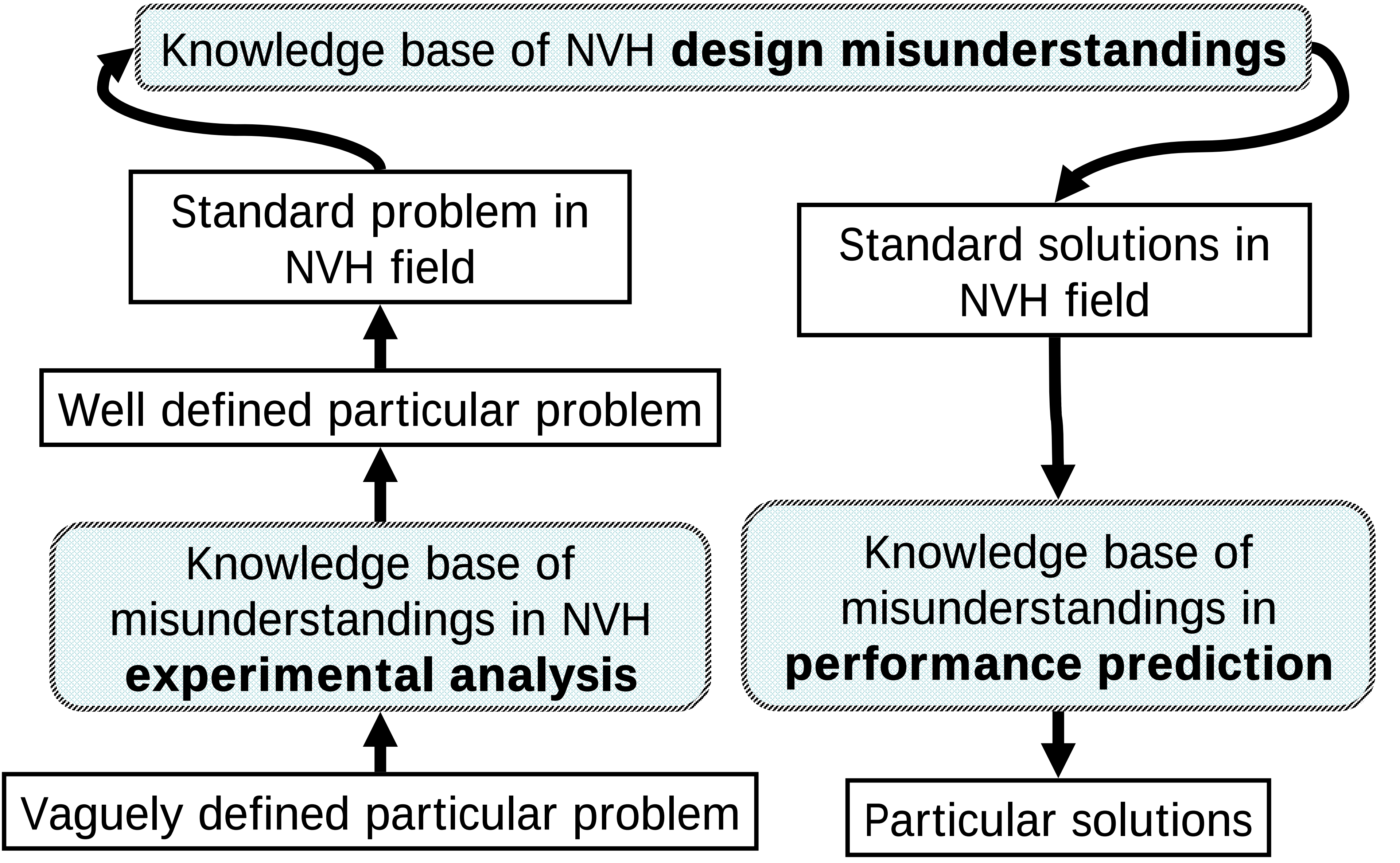
Usage of Resource Identification, Contradiction Matrix & Inventive Principles

Benefits: Can find best testing method

Risks:

Wrong selection of methods of experiment and simulation for predicting performances

TRIZ process with misunderstandings knowledge base

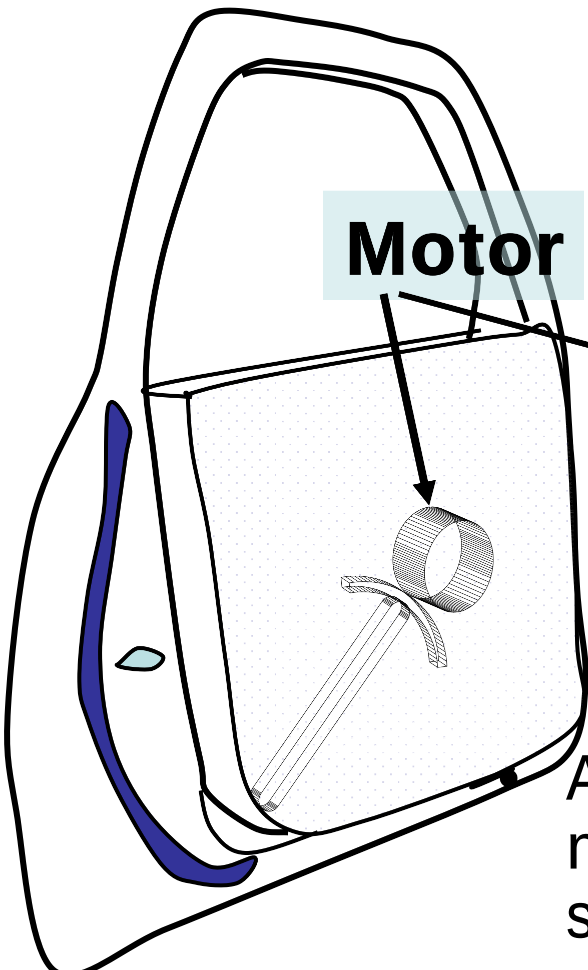


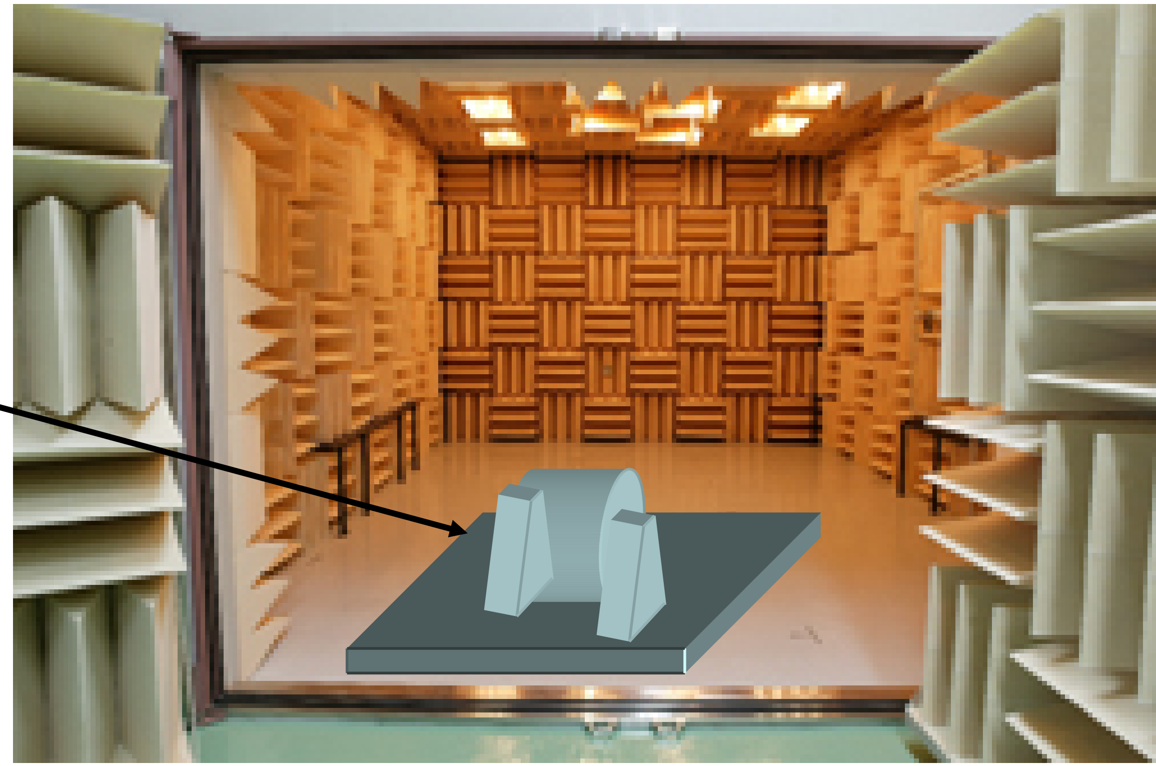
A List of Misunderstandings

One part of the list for conceptual design stage.
There are about 70 items in all.

Stage	Phenomena	Examples of misunderstandings	Performance, hardware or software concerned	Problems caused by the misunderstandings	Origin of the misunderstandings
ConceptGeneration	NVH General	Designating only output values (ex. Amplitudes) as specs.	Auxiary equipment	Overlooking of transmission efficiency caused by impedance mis-matching.	Insufficient knowldege in electric circuit theory
		Designing filters always on frequency domain	Signal processing	Cannot realize time-domain filters (impulse response) that really act	Superficial knowledge of Fourier Transform
		Applying only absorption (damping) or insulation alone.	Architectural acoustics	Vibration that does not reduces by damping, sound that does not reduces by insulation.	Overlooking input & output power balance
	Noise	Collision noise is generated only by structural vibration	Machine noise	Noise caused by flow collision is untreated	Poor education on sound & vibration relationship
		Sound propagating speed exeeds sound speed	Exhaust system	Miscalculation of resonant tube length	Insufficient knowledge of supersonic fluid dynamics
		Fail to recognize particle velocity as a vector	Active noise control	Misselection and misarrangement of actuator	Forgotten basid acoustics
		Confusion of mono-pole and die-pole sound sources	Active noise control	Misselection and misarrangement of actuator	Forgotten basid acoustics
ConceptGeneration	Vibration	Belief that damping of suspension or mounting is always useful	Engine mounting, suspension damper	Increase of transmission in high frequency range	Forgotten basid mechanics
		Universal joint transmitts just axial torque	Drive line	Vibration excitation near universal joints	Insufficient understanding of torque as vector
		Cord tension and lateral vibration oscillates at the same frequency	Belt or chain vibration	Wrong tuning of structure resonance	Lack of imagining physical movement
		Spacial waveforms of cords are sinusoidal	Belt or chain vibration	Wrong application of modal analysis	Lack of imagining physical movement
		Believing only even order harmonics dominate in four cylinder in-line engine excitation	Engine vibration & exhaust noise	Unnecessary search for non-linear effect or non-existing excitation sources	A fixed idea that the system is always symmetric

Designating only output values (ex. Amplitudes) as specs.

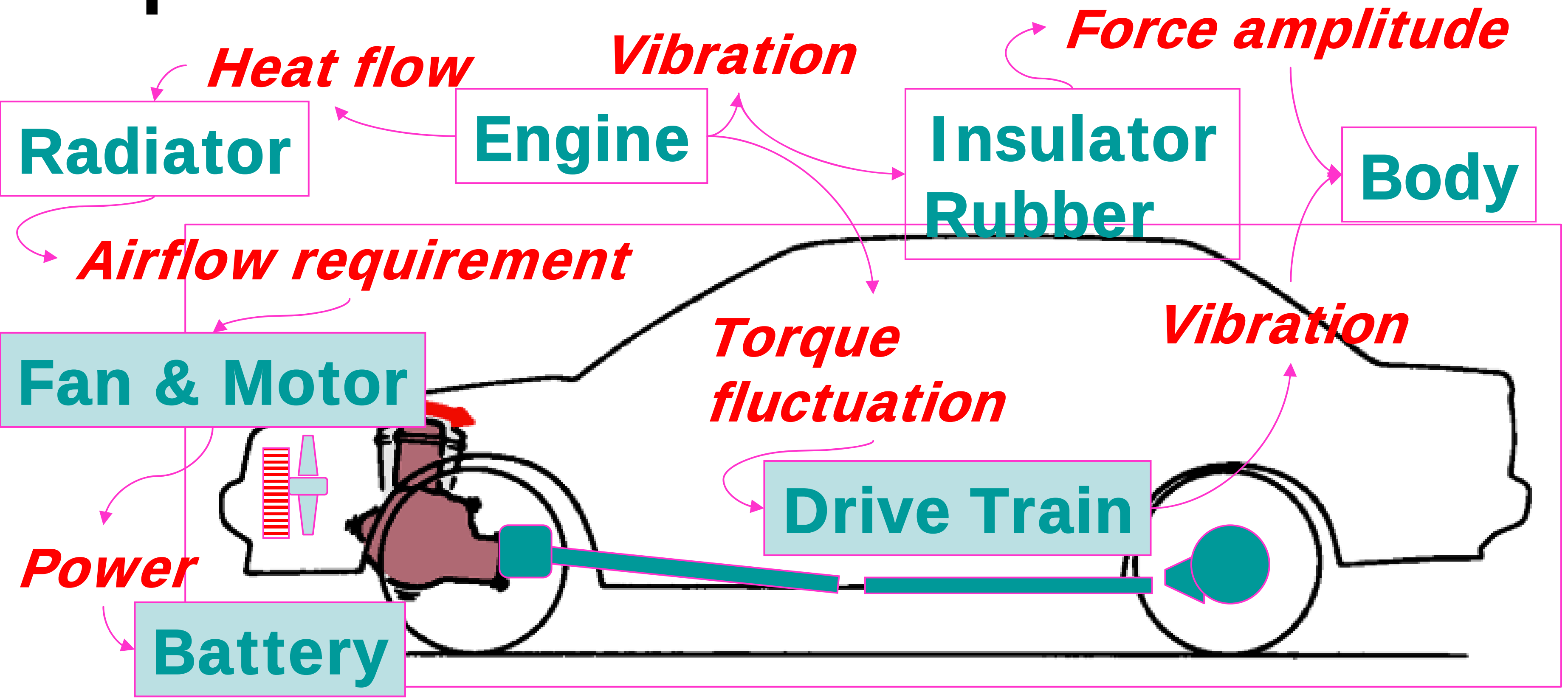




Amplitude is determined by the stiffness and mass balance between the main and sub structures.

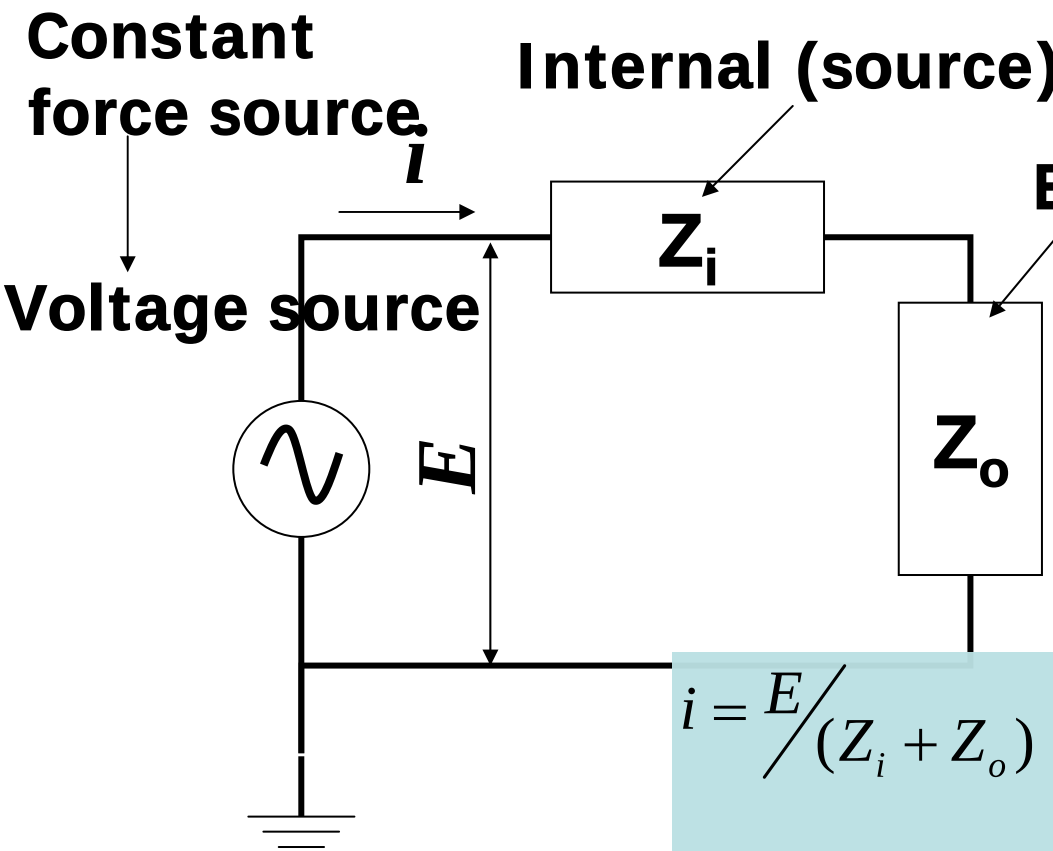
- Some engineers make mistakes of measuring noise/vibration in stand alone conditions.

Systematic design using coupling parameters as contract conditions



- Setting ambitious values as the coupling parameters promotes subsystem design progress.

Transmission efficiency caused by impedance mismatching.



Source impedance needs to be included in specifications

$$i = E/(Z_i + Z_o)$$

$$Output\ \ power: P = i^2 Z_o = \left\{ Z_o / (Z_i + Z_o)^2 \right\} E^2$$

$$P_{\max} = \left(1/4Z_o \right) E^2 \ \ for\ Z_i = Z_o$$