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Conception of Application of TRIZ to the Hard Disk Drive's Development

◉Hitachi Global Storage Technologies

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Introduction of HGST

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- **Hitachi Global Storage Technologies, Ltd.**
- **Year Founded:2003**
- **Employees:**
  Approximately 30,000 worldwide
- **U.S. Headquarters:**
  3403 Yerba Buena Rd.
  San Jose, CA 95135

- **Japan sites:**
    Odawara, Japan
        Established: 1966
        Focus: HDD development and production engineering.
    Fujisawa, Japan
        Established: 1972
        Focus: HDD development and launch,
                engineering support for OEM subsystems.

- **Global locations:**

  San Jose, California, U.S. / Odawara, Japan / Fujisawa, Japan
  / Shenzhen, China / Guadalajara, Mexico / Laguna, Philippines /Prachinburi, Thailand
  / Rochester, Minnesota / HSPC, China / Singapore / HGSP, Shenzhen, China

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Strategy for Promoting TRIZ
in HDD development activity

Strategy

- Physical Contradiction and Contradiction Matrix are very popular in the development engineers.

- Making the counterpart between parameters in Contradiction Matrix and HDD's technical parameters.

- Making the counterpart between 40 Inventive Principles and the patents used for the current HDD.

$\Rightarrow$ First fundamental step to promote TRIZ
in HDD development activities.

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Key Word of HDD parameter	TRIZ 48 Parameters
Bit length on the Disk	Length of stationary object(4)
Error Rate	Loss of Time (26)、Loss of Information (28)
Seek Time	Duration of Action of Moving Object (12)
Weight Saving	Weight of Stationary Object (2)
Sound	Noise (29)
Thermal Stability	Stability (21)
Track Per Inch	Information (11)
Reliability	Reliability (35)
Write Fault Frequency	Loss of Information (28)、Loss of Time (26)
Power Consumption	Loss of Energy (27)
Positioning Accuracy	Reliability (35)
Rotational Waiting Time	Loss of Time (26)
Cost	Productivity (44)
Radiation	Temperature (22)
Detectability of media defect	Ability of Detect/Measure (47)
Test Time	Loss of Time (26)、Productivity (44)

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Principles	Definition	Patents used for the HDD
1. Segmentation	Divide a system into separate parts or sections.	MR Head Thermal Flying Height Control Virtual Track Table
2. Taking Out	Where a system provides several functions of which one or more are not required at certain conditions, design the system so that they are or can be taken out.	Media Servo Write P2 Connector Adaptive Format
4. Asymmetry	Where an object or system is symmetrical or contains lines of symmetry, introduce asymmetries.	Streamline Suspension
6. Universality	Make an object or system able to perform multiple functions; eliminating the need for other system.	No ID Format
7. Nested Doll	Put one object or system inside another.	Wedge Servo
9. Preliminary Anti-Action	Where an action contains both harmful and useful effects, precede the action with opposite or anti-actions to reduce or eliminate the harmful effects.	RRO Feed Forward Write Compensation
10. Preliminary Action	Introduce a useful action into an object or system.	Look Ahead Function
11. Beforehand Cushioning	Introduce emergency backups to compensate for the potentially low reliability of an object.	Reassign Function ECC Function

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Actual Example
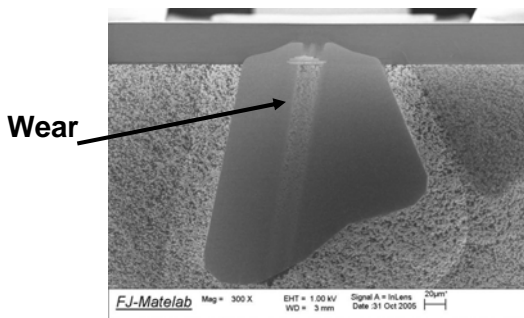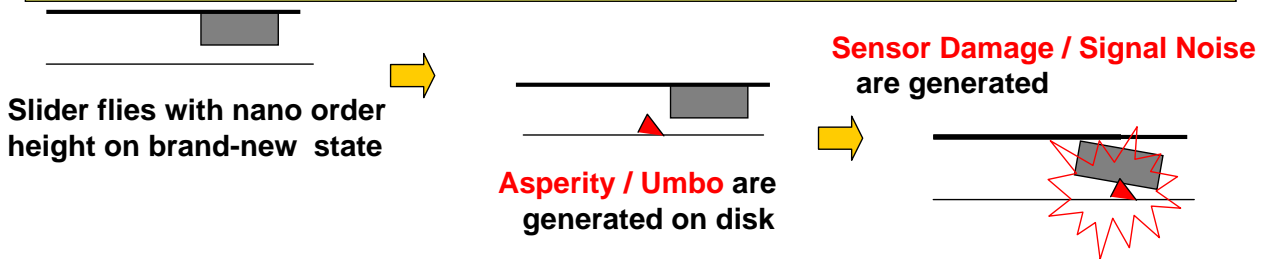
1. Low RPM Error Recovery

- Application of Contradiction
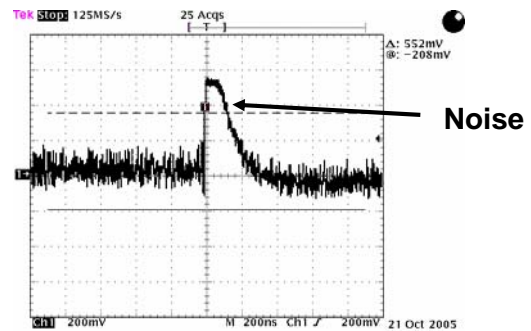
2. Actuator Design for High Accuracy Head Positioning

- Breakthrough of "Psychological inertia"

- Function box chart applied to design flow

Example-1 Background

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Sensor damage and signal noise occur easily due to nano size particle or nano size scratch on the disk surface.

Slider flies with nano order height on brand-new state

Asperity / Umbo are generated on disk

Sensor Damage / Signal Noise are generated

Wear

Noise

Sensor Damage

Signal Noise

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Improving Feature : **Lower Flying Height on the Disk**

- 3：Length/Angle of Moving Object

Worsening Feature : **Increasing Electrical Noise of Data**

Increasing Slider's Sensor Damage

- 29： Noise
- 35： Reliability / Robustness

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- Lower Flying Height on the Disk makes Electrical noise / Reliability worse.

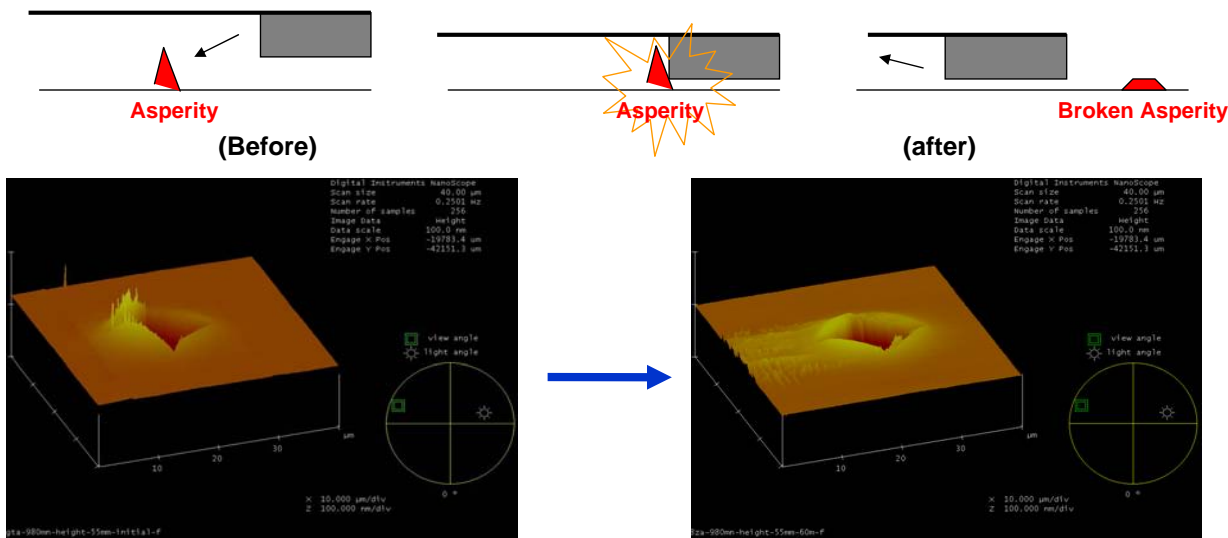- Inventive Principles from the Contradiction Matrix

  - 3 x 29
    - **17： Another Dimension**
    - **3： Local Quality**
    - **1： Weight of Moving Object**
    - **13： Duration of Action of Stationary Object**
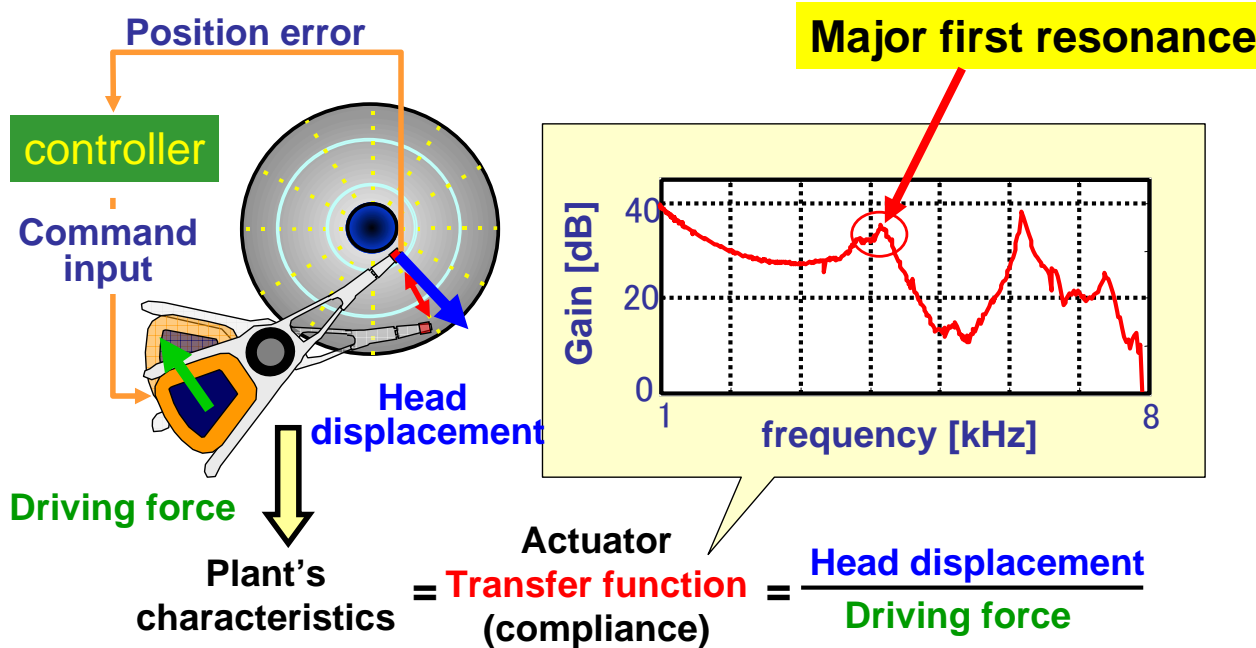
  - 3 x 35
    - **35： Parameter Change**
    - **10： Amount of Substance**
    - **14： Speed**
    - **17： Another Dimension**

If an object moves in a straight line, consider use of dimensions or movement outside the line.

=> Low RPM Error Recovery

Step-1 : Signal noise appear during operation
Step-2 : Reduce disk's rotational speed (RPM) and flying height
Step-3 : Hit against an asperity
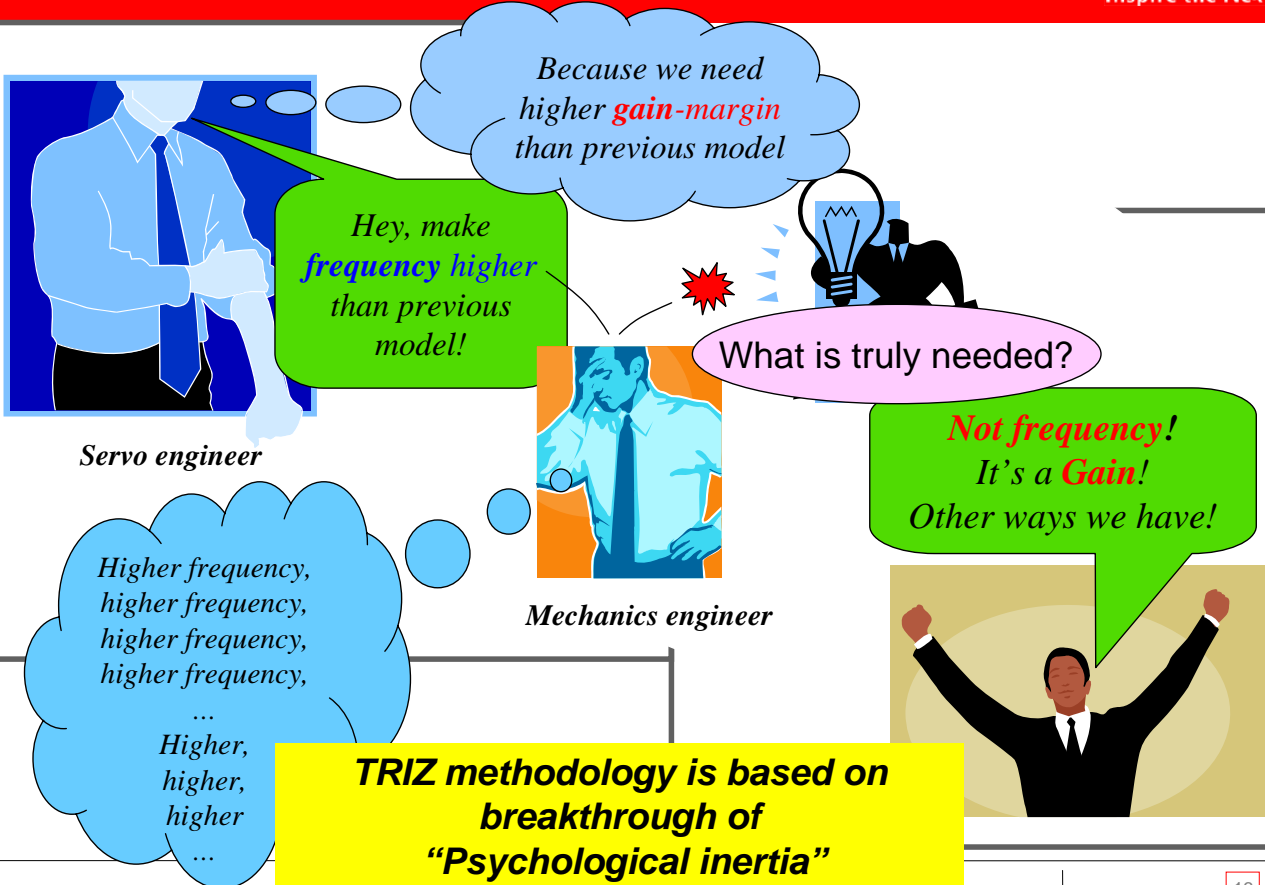Step-4 : Back to the normal RPM and the flying height

Asperity

(Before)

Asperity

Broken Asperity

(after)

Example-2 Description of actuator dynamics

Major first resonance

Position error

controller

Command input

Driving force

Head displacement

Gain [dB]

frequency [kHz]

Plant's characteristics = **Transfer function** (compliance) = **Head displacement** / **Driving force**
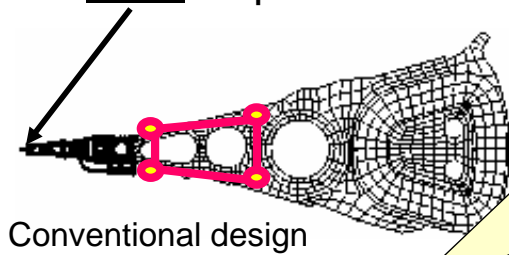
Actuator

Higher "servo bandwidth" is necessary to improve servo suppression ability.
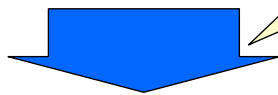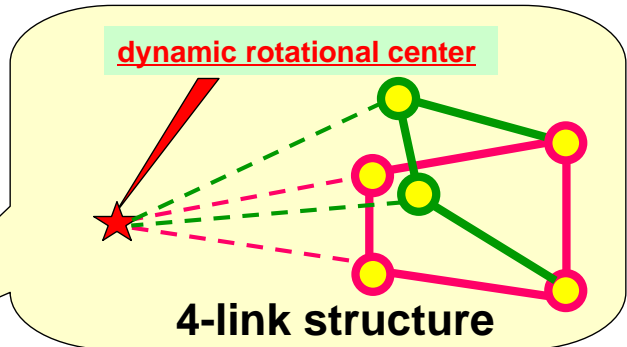
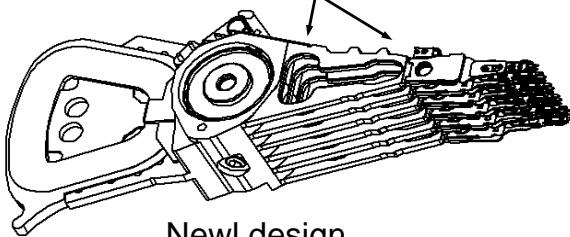**"Major first resonance" defines the servo bandwidth**

Break through "PSYCHOLOGICAL INERTIA"

*Because we need higher **gain**-margin than previous model*

*Hey, make **frequency** higher than previous model!*

Servo engineer

What is truly needed?

Not frequency! It's a Gain! Other ways we have!

Higher frequency, higher frequency, higher frequency, higher frequency, ... Higher, higher, higher ...

Mechanics engineer

TRIZ methodology is based on breakthrough of "Psychological inertia"

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Mechanical design based on new design strategy

Reduction of gain of the first resonance

= Zero <u>head</u> displacement

Conventional design

dynamic rotational center

4-link structure

hinge

Newl design

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Classical TRIZ

TRIZ software

"TechOptimizer"
"IWB (Innovation Work Bench)"

Problem,
Function,
Background,
→ **Function box chart** → **Hint**

•Original usage: description of action, reaction and function

•Our novel usage: description of design flow

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