Software Process Lines and Standard Traceability Analysis

WOCS 2009, Tokyo, Japan

Alexis Ocampo
Ove Armbrust

Fraunhofer IESE
Kaiserslautern
Germany

Fraunhofer Institut
Experimentelles
Software Engineering

Fraunhofer Institute for Experimental Software Engineering (IESE)

- Background:
    - Founded in 1996
    - 200 employees
    - Located in Kaiserslautern (Germany)

- Characterization:
    - Competence Center for Software Engineering
    - Center for Empirical evaluation of methods and techniques

- Activities in the area of software processes:
    - Capture and model software processes
    - Process enhancement programs

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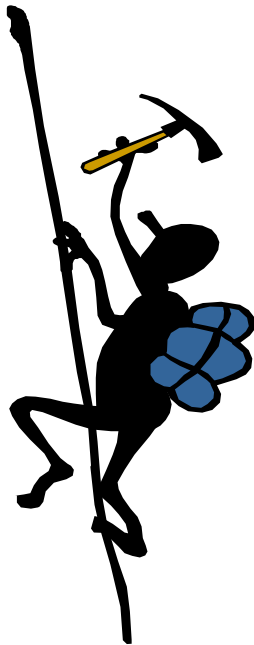Ove Armbrust
2009-01-15
WOCS 2009, Tokyo, Japan

Agenda

- Software Process Lines
  - Challenges
  - Approach
  - Conceptual Model
  - Example
  - Benefits
  - Experience

- Standard Traceability Analysis
  - Challenges
  - Approach
  - Example
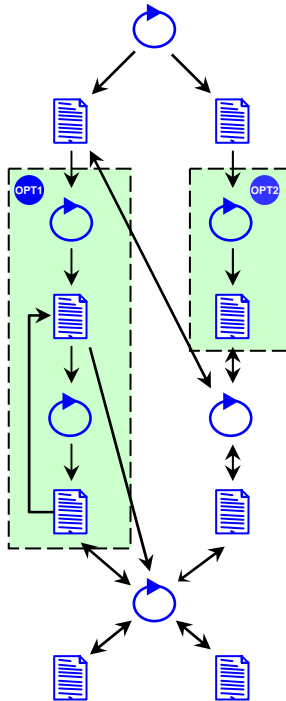 - Benefits
  - Experience

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Software Process Lines: Challenges

- Highly dynamic business context

- Organizations continuously adapt their processes

- Frequently changing process-support technology

- Large number of processes that vary in relatively minor ways can lead to
  - redundancy
  - lack of consistency
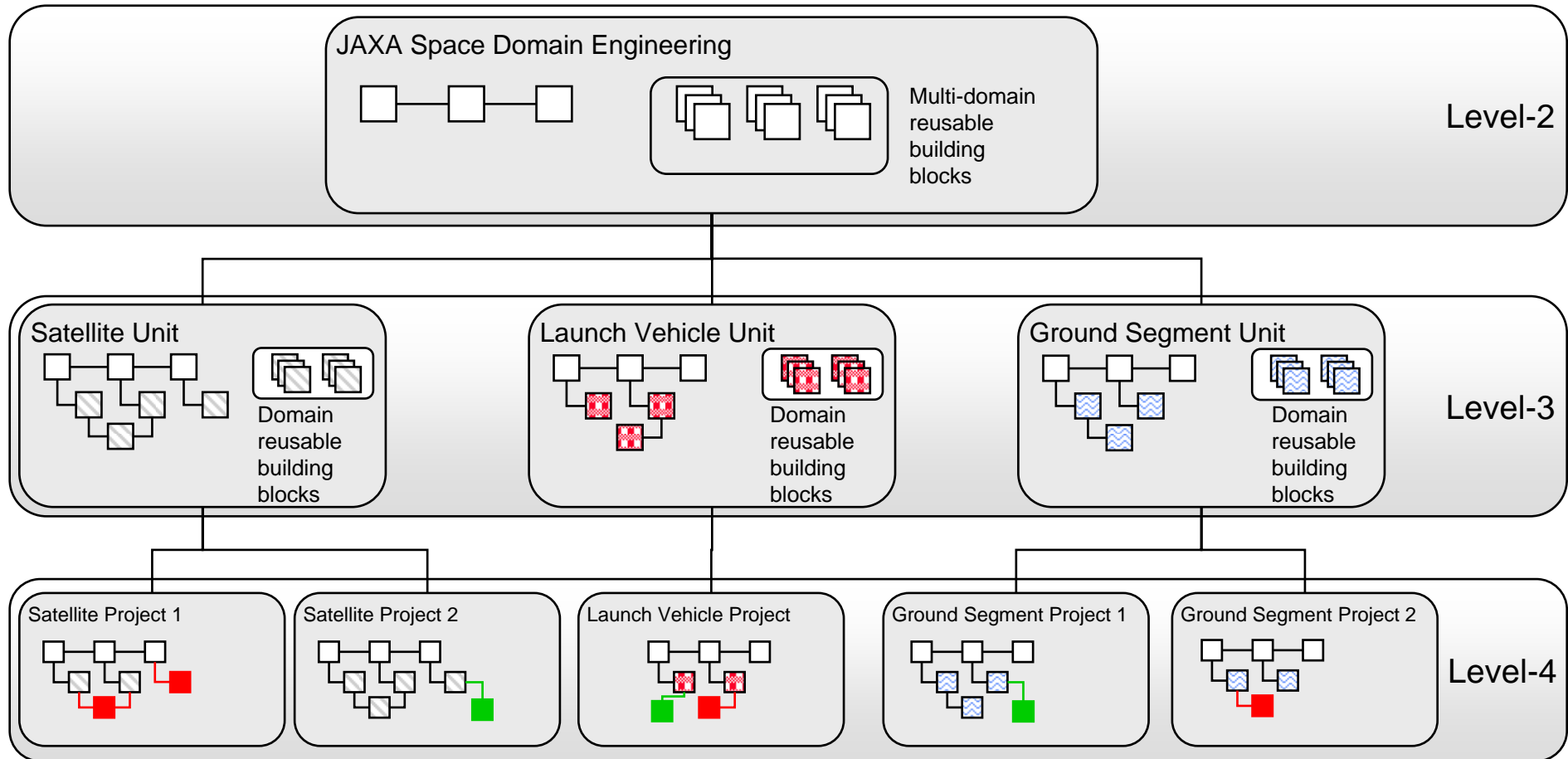 - high maintenance costs

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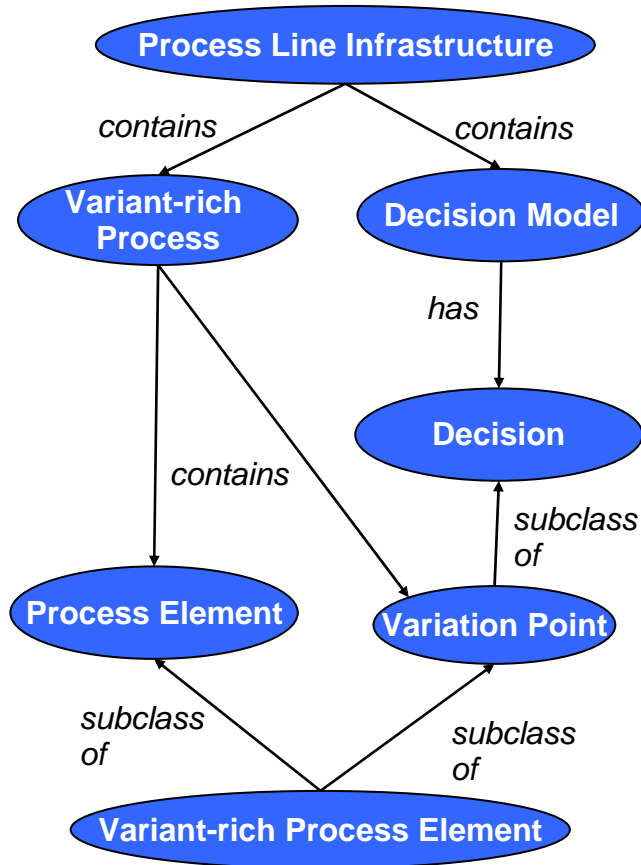
Software Process Lines: Approach

- Realize reuse at a large scale for JAXA software engineering standards

- Transfer the concepts of software product line engineering to JAXA software engineering standards

- The underlying idea is to reuse common parts of related software engineering standards

- Analyze commonalities and differences between software engineering standards in order to:
  - identify process variants and justifications
  - integrate them systematically in a software engineering process line

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Software Process Lines: Overview

JAXA Space Domain Engineering

Multi-domain reusable building blocks

Level-2

Satellite Unit

Domain reusable building blocks

Launch Vehicle Unit

Domain reusable building blocks

Ground Segment Unit

Domain reusable building blocks

Level-3

Satellite Project 1

Satellite Project 2

Launch Vehicle Project

Ground Segment Project 1

Ground Segment Project 2

Level-4

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Software Process Lines: Conceptual Model

Process Line Infrastructure

contains

contains

Variant-rich Process

Decision Model

has

Decision

contains

Process Element

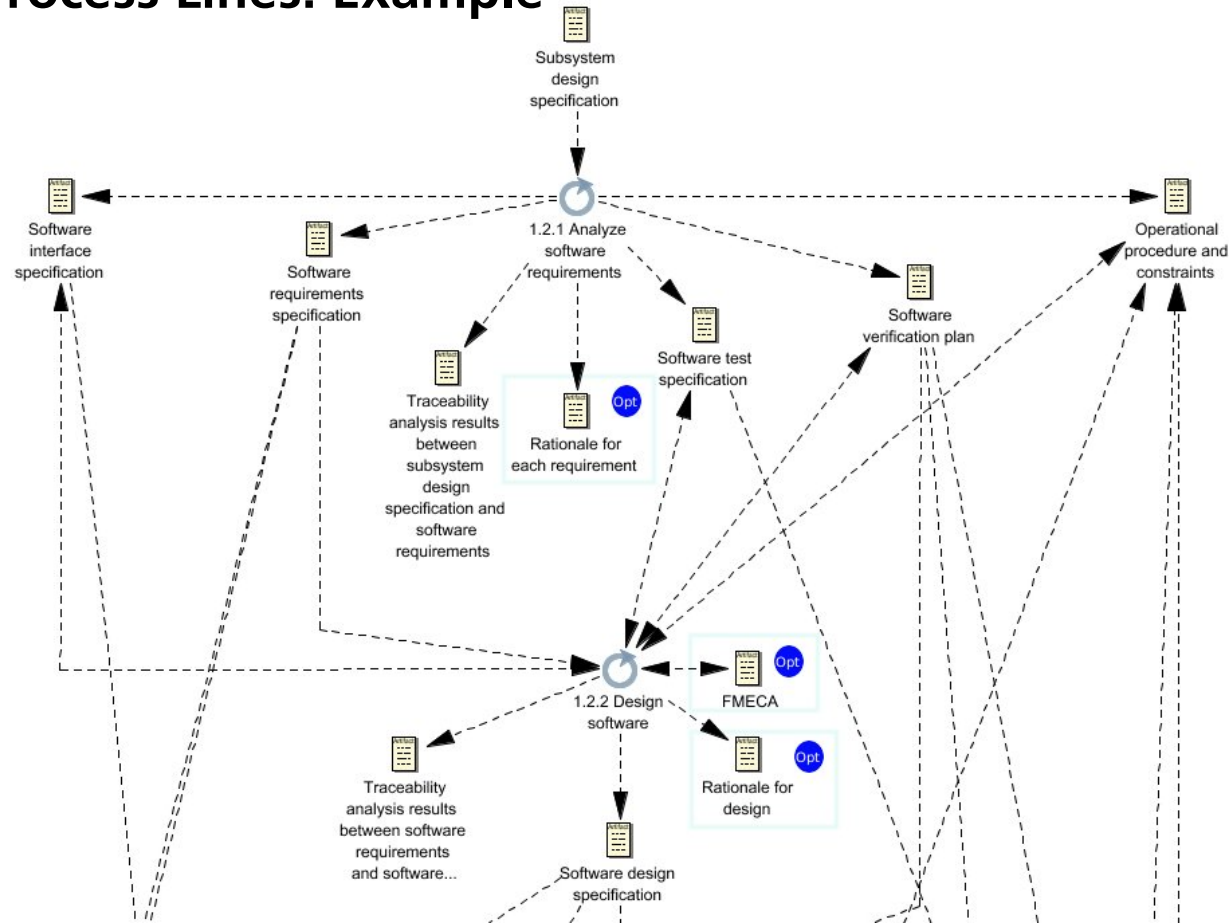**Variation Point**

subclass of

subclass of

subclass of
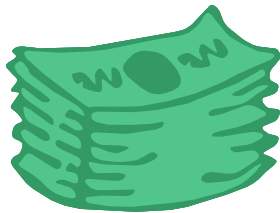
Variant-rich Process Element

- A process line infrastructure contains
  - variant-rich processes
  - decision models

- A variant-rich process contains
  - process elements, e.g., role, tool, activity.
  - variation points

- A variant-rich process element is
  - a process element and a variation point

- A decision model contains
  - decisions, i.e., variation points that constrain the resolution of other variation points

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Software Process Lines: Example

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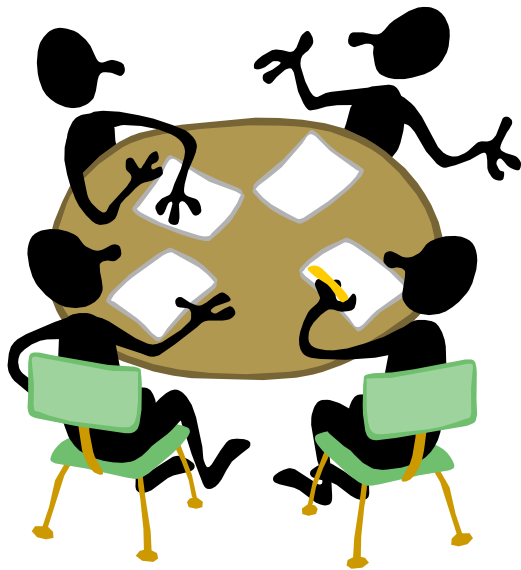**Fraunhofer** Institut
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Software Process Lines: Benefits

- Process Management:
  - Avoids the proliferation of redundant processes by establishing a common infrastructure
  - Enables systematic inclusion of possible new processes in the common framework by means of variation points

- Executive decision making: Helps managers on deciding which processes are suitable for certain types of projects, so that they proceed more effectively and efficiently

- Outsourcing: The commonality analysis provides a basis for integrating processes between an outsourcing organization and its suppliers

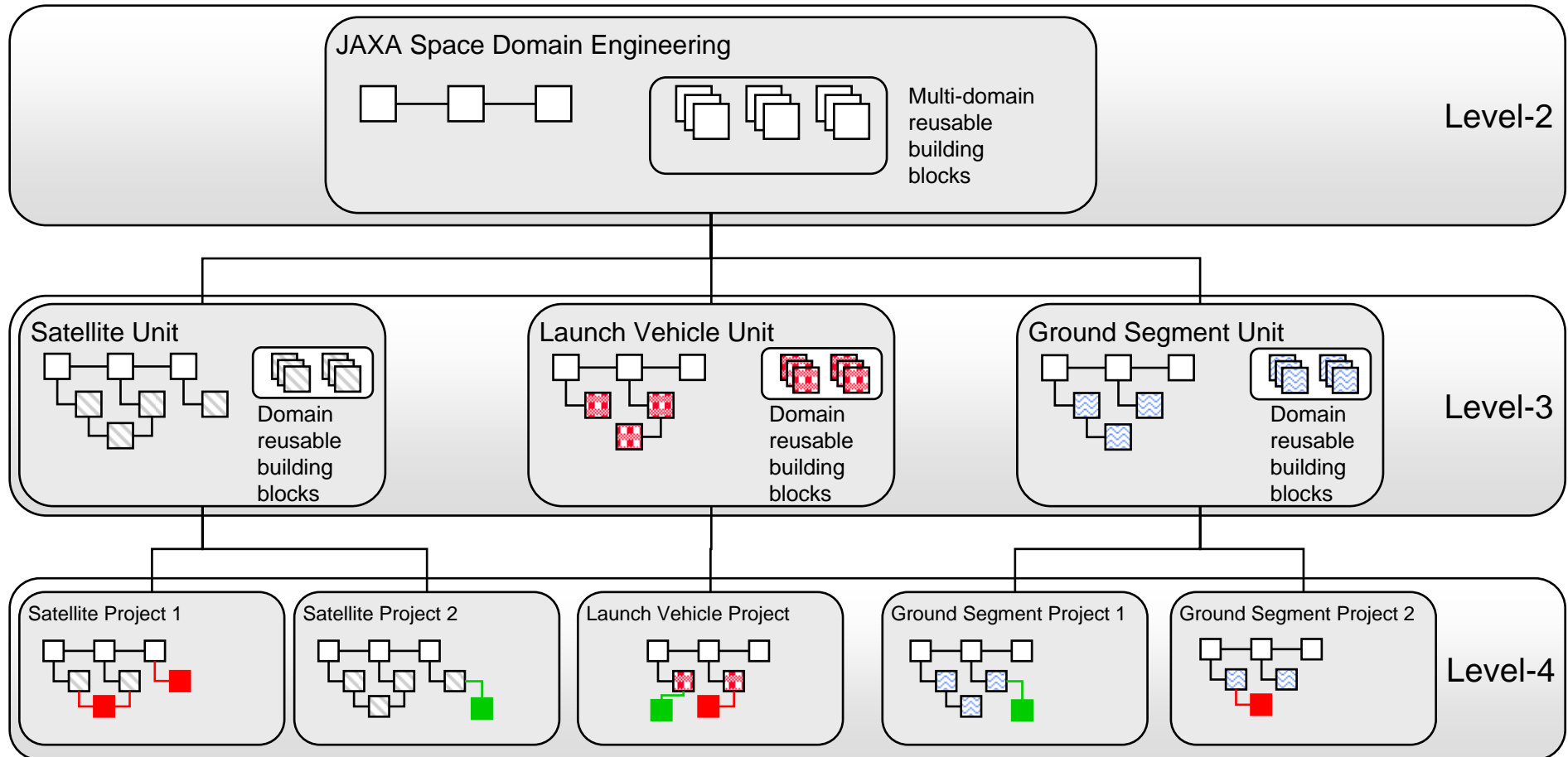- Tailoring guidance: Notations for describing common and alternative process parts support tailoring

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Software Process Lines: Experience

- JAXA (from 2007, ongoing)

  - Software development standards for satellite development used as input for feasibility study at JAXA

  - Commonality analysis led to identification of variation points and their rationale

  - The initial process line resulted in:

    · 76 activities

    · 54 artifacts

    · 18 product flow views

    · 8 variation points

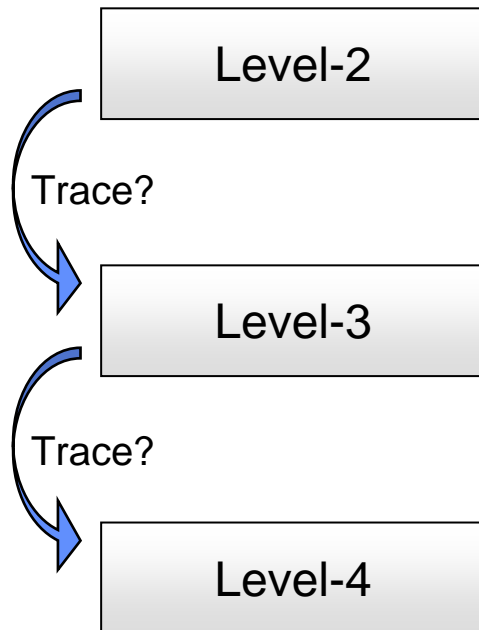 - Planned as Annex to an upcoming JAXA level 3 standard

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Standard Traceability Analysis: Challenges

- Reminder: standards architecture

Standard Traceability Analysis: Challenges

| Level-2 |

Trace?

| Level-3 |

Trace?

| Level-4 |

- How to establish and maintain traceability between levels?

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Standard Traceability Analysis: Challenges

Level-2

↑ Compliant?

Level-3

↑ Compliant?

Level-4

- How to establish and maintain traceability between levels?

- How to prove compliance of lower-level standards to higher-level standards?

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Standard Traceability Analysis: Challenges
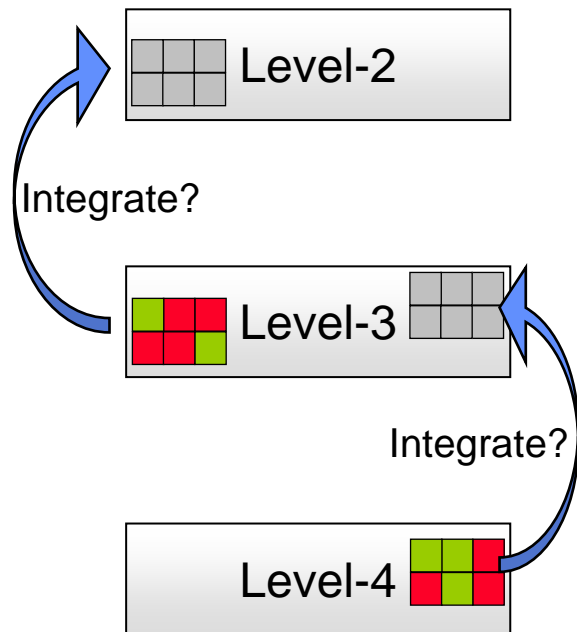

Level-2

Change?

Level-3

Change?

Level-4

- How to establish and maintain traceability between levels?

- How to prove compliance of lower-level standards to higher-level standards?

- How to propagate changes of higher-level standard to lower-level standards?

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Standard Traceability Analysis: Challenges

Integrate?
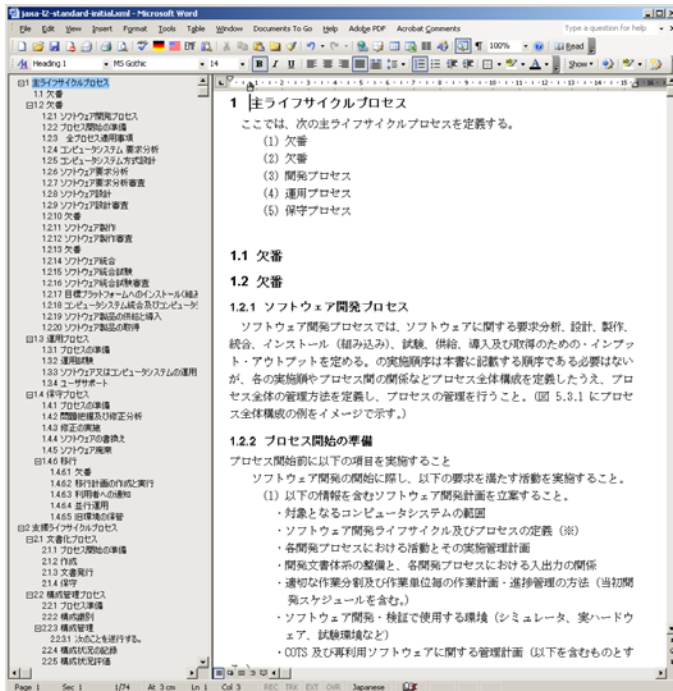
Integrate?

Level-2

Level-3

Level-4

- How to establish and maintain traceability between levels?

- How to prove compliance of lower-level standards to higher-level standards?

- How to propagate changes of higher-level standard to lower-level standards?

- How to integrate changes from lower-level standards into higher-level standard?

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Standard Traceability Analysis: Challenges

- How to establish and maintain traceability between levels?

- How to prove compliance of lower-level standards to higher-level standards?

- How to propagate changes of higher-level standard to lower-level standards?

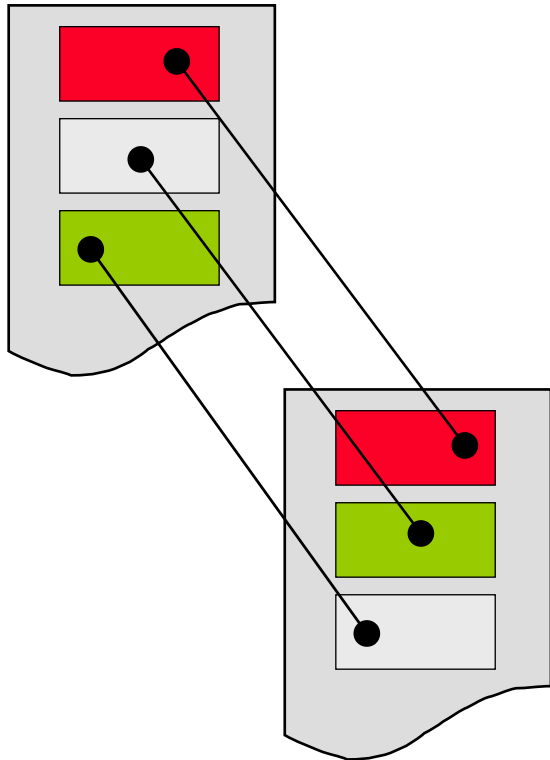- How to integrate changes from lower-level standards into higher-level standard?

- How to support standards editing in word processor?

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Standard Traceability Analysis: Approach

- Traceability between standards on process entity level
  - activities
  - workproducts

- Unique, invariant IDs for activities, workproducts

- Persistent link between entities in word processor through IDs

- Word processor file parsed and analyzed using database

- Record of changes, type of trace (unchanged, modified, new, …)

- All editing done in word processor file

- Example…

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Level 2 Standard

1.3.2 Computer system requirement analysis

Meta Data	
Change Log	
Activity ID	6
Changes	

Activities that meet the following requirements shall be conducted for computer systems:

(1) Requirement elicitation

The operational concept of computer systems to be developed shall be analyzed and operational scenarios shall be generated.

(2) Requirement specification development

Feasibility and consistency shall be checked based on the operational scenario, and requirement specifications for computer systems shall be defined.

The rationale of requirement specifications for computer systems shall be clarified, and the traceability relative to high-order requirements such as requirements for computer systems shall be evaluated.

Work Products	
Inputs	
7	Requirements regarding computer systems
8	Operational concept
Outputs	
4	Operational scenario
5	Requirement specifications regarding computer systems
6	Evaluation result of traceability relative to high-order requirements

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Level 3 Standard

1.1.3 Computer system requirement analysis

Meta Data		
Change Log		
Activity ID	5	
Changes		
Master Coverage		
Master Activity ID	Compliance	Comments
6	M	The Level 2 standard output "Requirements specifications regarding computer systems" is contained in the "System operational requirements" output of this activity.

Activities that meet the following requirements shall be conducted for computer systems:

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Additional Meta Information

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Level 2 Standard

Level 3 Standard

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Invariant Activity ID

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Level 3 Standard

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per-activity Change Log

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analysis

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Inputs and Outputs with invariant IDs

1.1.3 Computer system requirement analysis

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Level 3 Standard

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Activity Traceability

Standard Traceability Analysis: Benefits
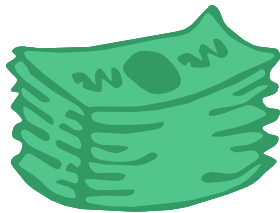
- Workflow for editors of standard only marginally changed because of word processor integration

- Traceability immediately visible for editors

- Powerful analysis and reporting capabilities through database

  - Statistical analyses (progress reports)
  - Which level 2 activities were removed on level 3?
  - Which activities were modified from level 2 to level 3?
  - Do level 2 changes affect level 3 standards?

- Review support through automated consistency checks:

  - Which output is produced, but never used?
  - Which input is used, but never produced?

- Tedious and error-prone activities executed by machine, humans can concentrate on important tasks

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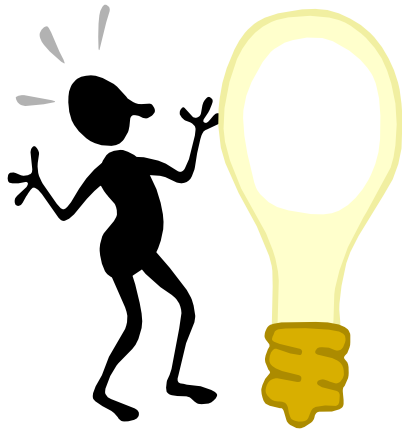# Standard Traceability Analysis: Experience

- ESOC (ESA ground segment, 2004)
    - Edited ESA Ground Segment (SETG) standard to provide full compliance to ECSS requirements
    - Provide compliance proof: traceability table listing every requirement
    - ECSS: about 1600 requirements
    - SETG: about 100 pages
    - Traceability Tables: about 65 pages
- JAXA (from 2008, ongoing)
    - Traceability between level 2 and level 3 standards
    - Traced entities: Activities, workproducts
    - Consistency checks (product flow) support
    - JAXA engineers edit standards
    - IESE provides consistency and traceability reports

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Conclusions

- Process Line approach allows for consistent, lean standards across JAXA space engineering

- Product Line concepts with adaptations applicable to processes

- Traceability between different levels, standards challenging

- Word processor based approach feasible

- Automated consistency checking helps JAXA engineers to concentrate on important work

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Thank You For Your Attention!

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