

Application of Goal Structure Notation (GSN) in IV&V Activities

~ NASA's 2014 International IV&V Workshop ~

JAXA's Engineering Digital Innovation Center

IV&V Team

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Part 1 : Background : Concept and Issues of JAXA' s IV&V

1. Brief history of IV&V activities in JAXA
2. Characteristics of JAXA' s IV&V activities
3. Clarification of IV&V NEEDS
4. Value Concept of JAXA IV&V activities in recent years
5. Issues of JAXA IV&V activities
6. What is GSN ?
7. Expectation for GSN

Part 2 : Application of Goal Structure Notation (GSN) in IV&V Activity ~IV&V case~

1. Concept of IV&V case
2. Devised point for Introducing of IV&V case (1/4)
3. Introduction effects of IV&V case
4. Future work of IV&V case

Summary

Part 1 Background: Concept and Issues of JAXA's IV&V



Start of IV&V
(over decades ago)



Apply to
various
projects



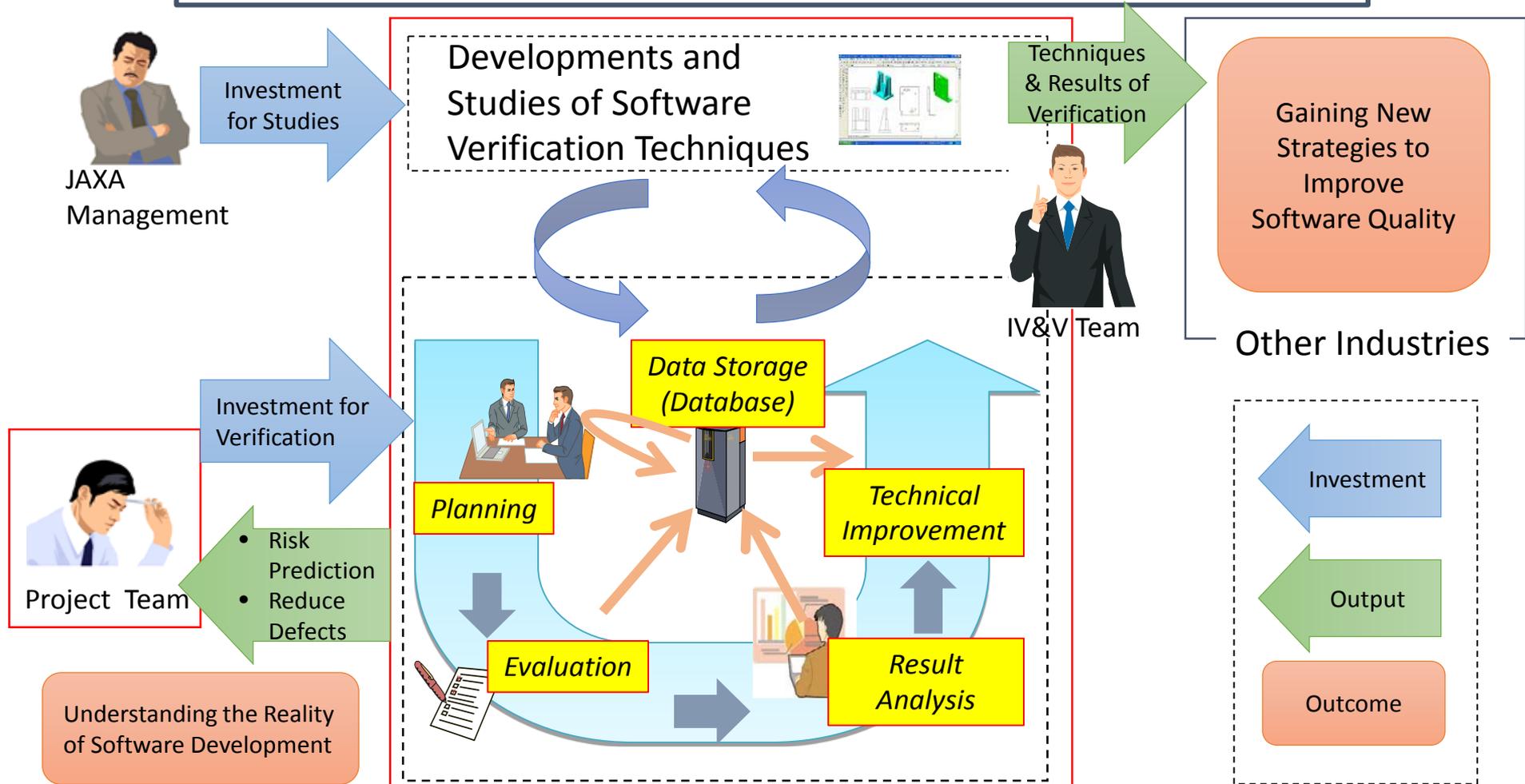
NOW



IV&V Program become widespread
→ NEEDS are changed

Characteristics of JAXA's IV&V activities

- Beneficiaries pay IV&V costs (Projects have funds).
- IV&V is finished when a result is reported to a project team.



- NEEDS 1: Clear accountability for “Confidence”
- NEEDS 2: “Guarantee” the SW quality as a whole
- NEEDS 3: Show traceability between SW defects on orbit and operational risks.

BEFORE

- Figure out significant problems of software development.
- Understand verification attributes and scope of IV&V.
- Finish up with merely identifying the problems.

NOW

Confidence

- Gain a future advice and judgment stuff for development which can be learned from software defects.

Guarantee

- Know how much IV&V contributed to the high-reliable software together with V&V.

Improvement

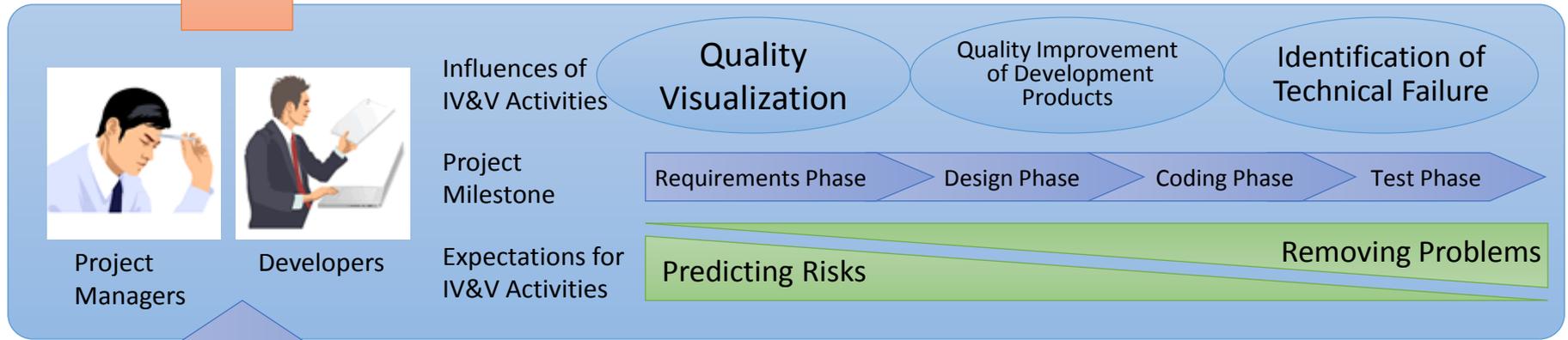
- Understand how software problems influence on operations. Traceability between software defects and risk for operations is required.

Value Concept of JAXA's IV&V activities in recent years



Product Customers Executives

Promote Confidence (Reassurance)
Does the software meet the customer's needs?
Reduce Risks in Development/Operation
Identify deficiencies, usually detected in the late development phase or operational phase, early in the development lifecycle.



to be more effective . . .



IV&V Team

Suitable planning for each project based on the data

Storage of Cost-benefit Data per Attribute/Method

Analysis of Characteristics of the Target Products

- Use IV&V knowledge across projects.
 - Store information of identified problems.
- Set verification attributes from a system-building/operational viewpoint.
 - Define verification attributes after identifying important functions and scenes in missions or operations.
- Establish verification techniques different from developers.
 - Improve IV&V Manual, make use of Formal Method, etc.

■ Issues

- We does not fulfill accountability to the stakeholders, the value of IV&V is not understood.
- For accumulation and application of the knowledge of IV&V has not been, We cannot exert the strengths and originalities of IV&V.
- Transfer of the IV&V engineers are frequent and we cannot maintain the quality of IV&V as an organization.

■ Solutions



- It is necessary to show the scope and evidence that evaluated by IV&V for the stakeholder.



- It is necessary to identify what is the valuable knowledge for IV&V activities.

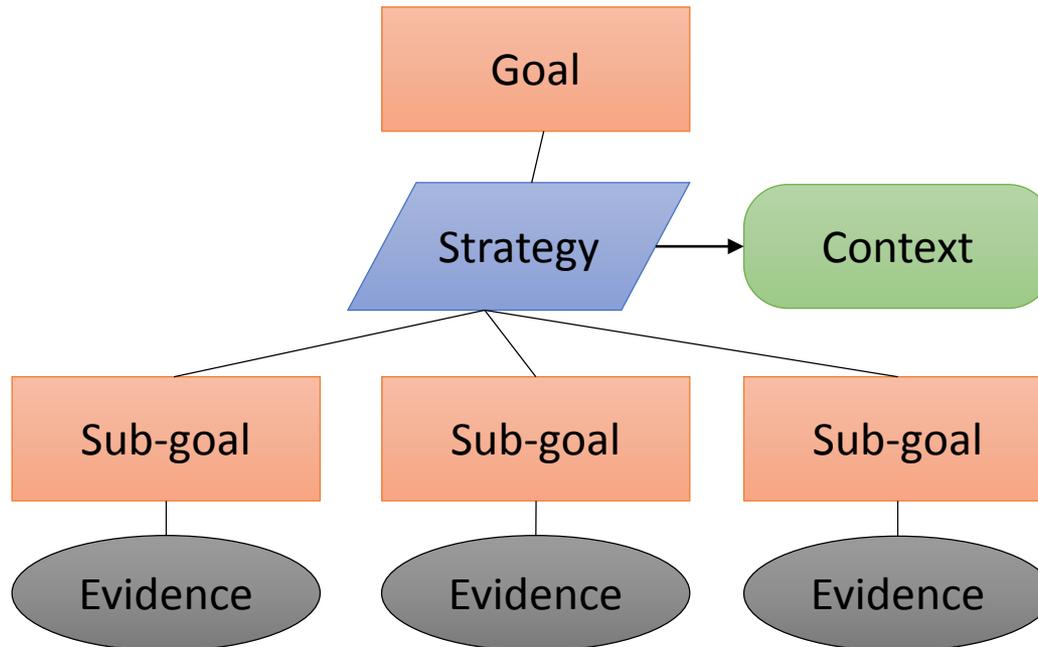


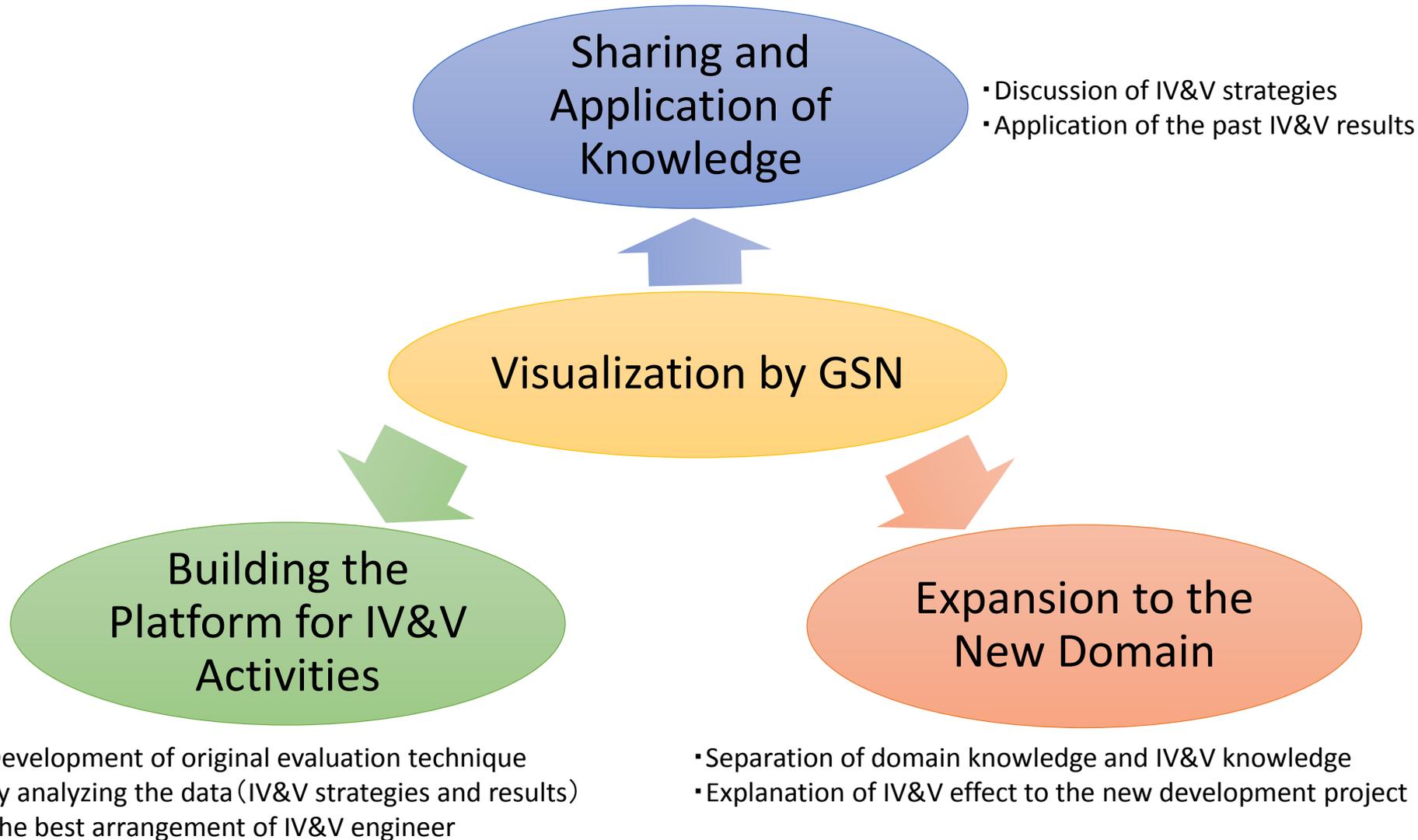
- Even IV&V beginner engineer, It is necessary to make the structure on which can perform IV&V with quality of the constant level.



We devised “IV&V case” utilized GSN (Goal Structuring Notation), introduced it to IV&V activities.

- GSN is a graphical argument notation which can be used to document explicitly the elements and structure of an argument and the argument's relationship to evidence.
- In GSN, the claims of the argument are documented as goals and items of evidence are documented in solutions.





Part 2

Application of Goal Structure Notation (GSN) in IV&V Activity

~ IV&V case ~

Visualization of Risk-based IV&V

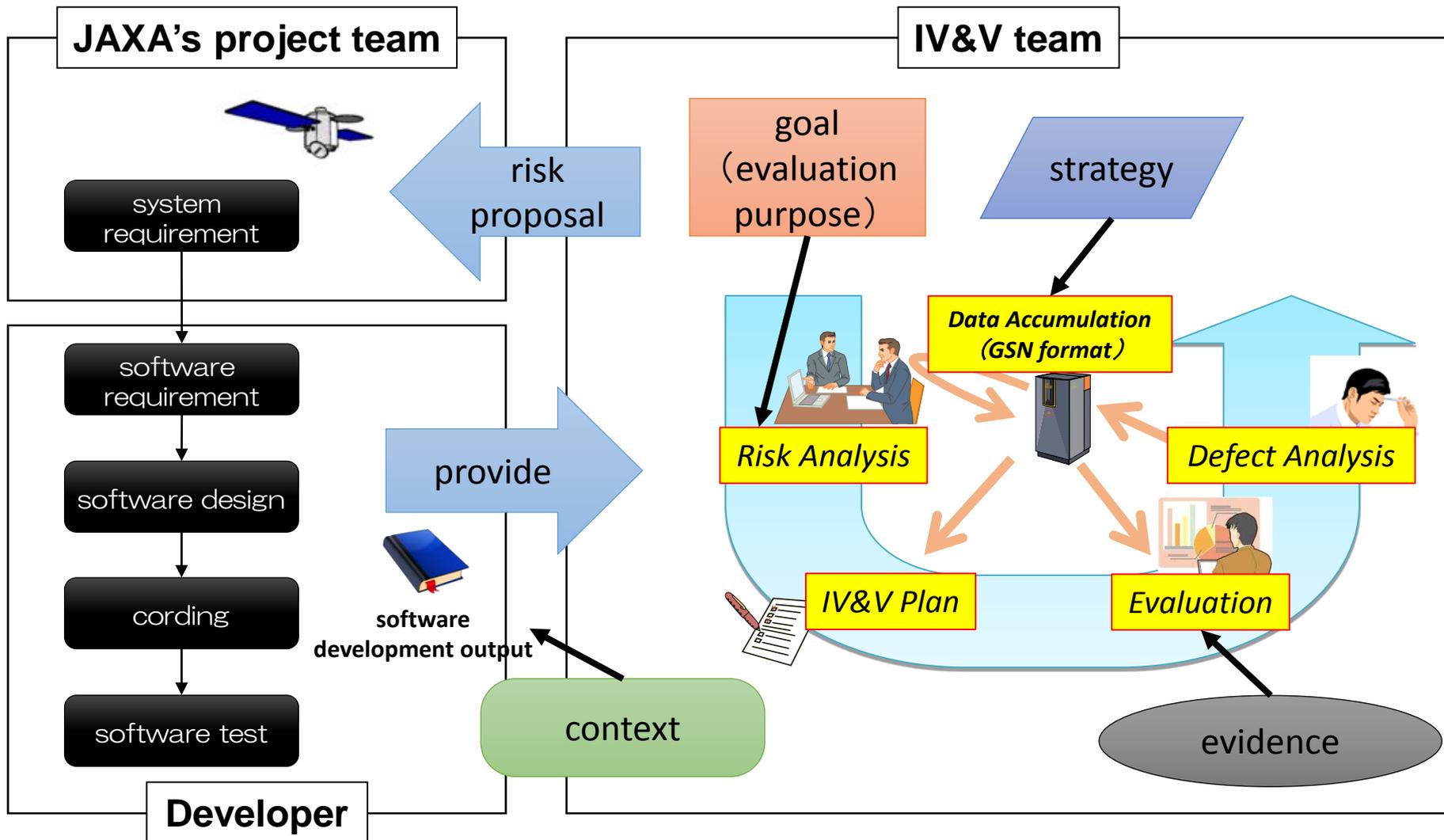
- IV&V strategy based on risk

IV&V Original Strategy

- take different strategy from developer(V&V) by using information across projects (ex. defect information).

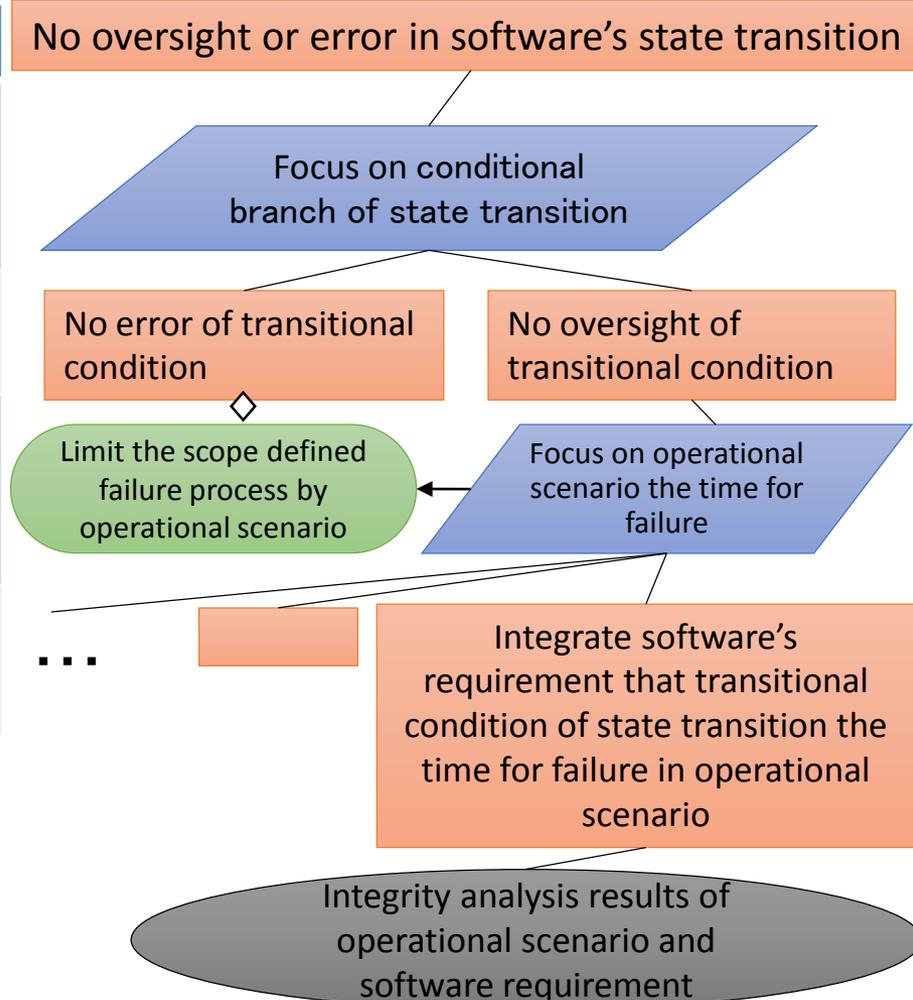
Estimate of Evaluation Accuracy

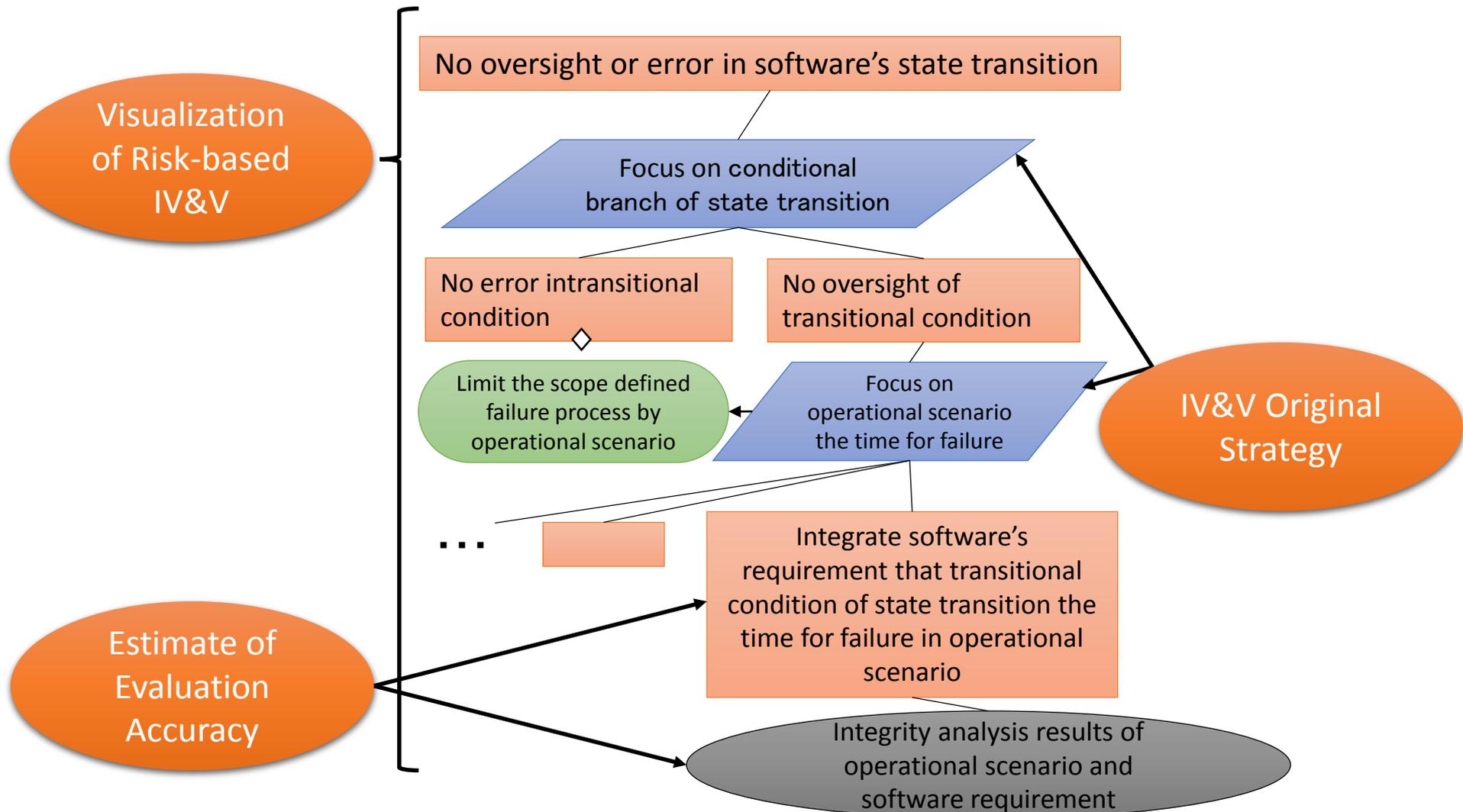
- prepare evidence assumed at the time of IV&V planning



Position of node

Node	Position on IV&V case
goal	Evaluation Purpose (There is no risk of a particular)
context	Specification Information
strategy	Evaluation Attribute (Observation point to achieve evaluation purpose)
evidence	Evaluation Result



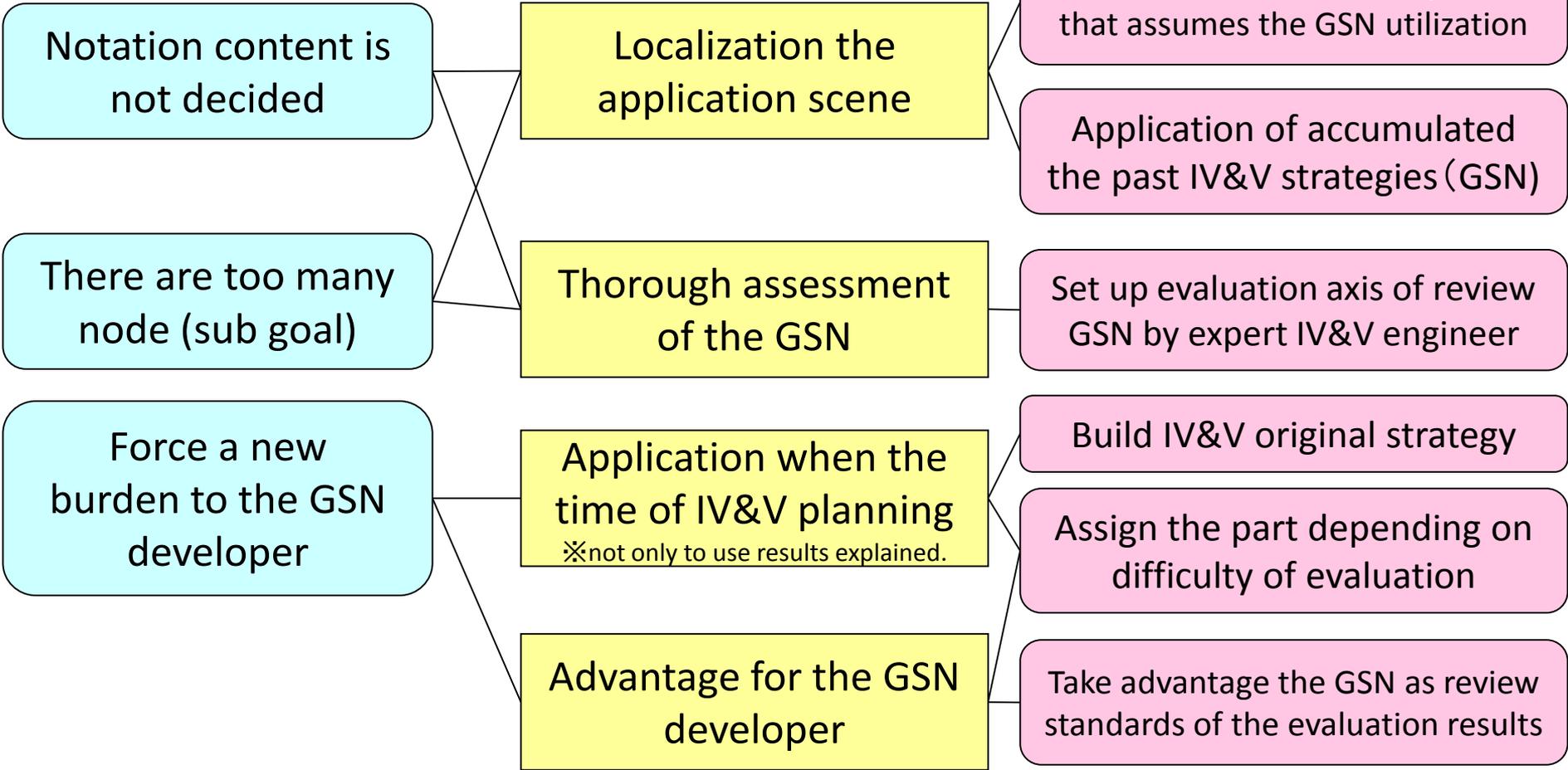


To give advantage to GSN developer

Examples of the Problem in the introduction of the GSN

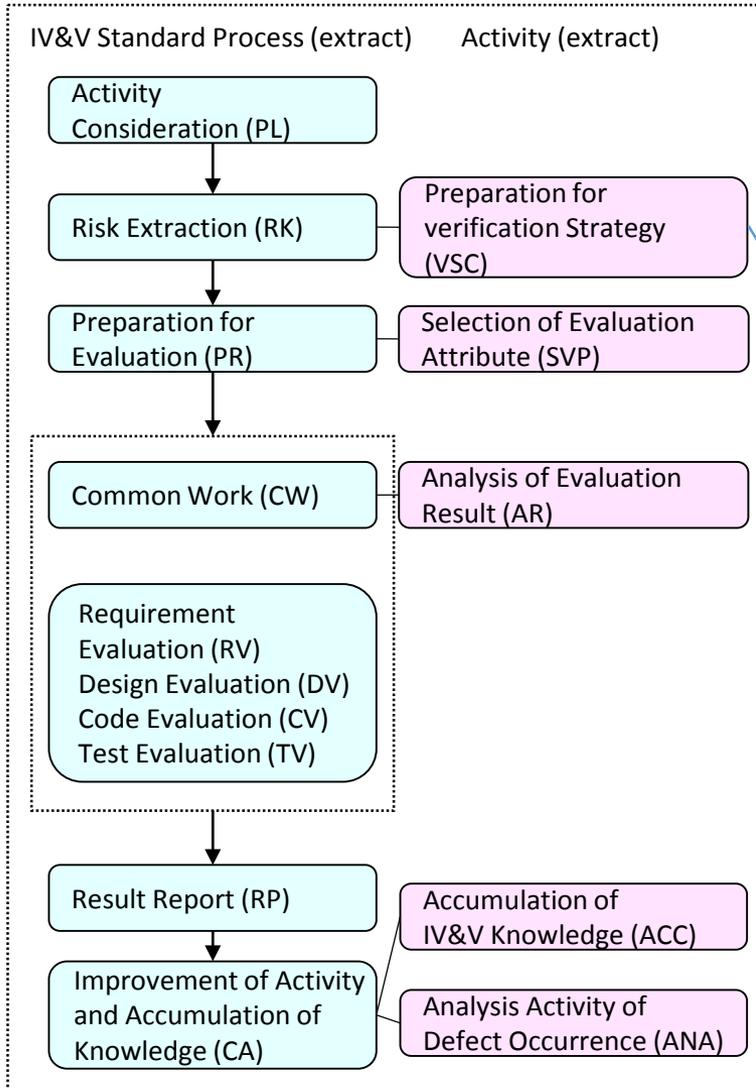
Devised points of IV&V case

Work results in IV&V activity



Devised point for Introducing of IV&V case (2/4)

Depending on application scene,
decide completion standard and application purpose



■ User and Purpose

- IV&V program leader → JAXA's project team
 - ✓ To understand the difference between IV&V and V&V by explaining IV&V strategy for the purpose of the IV&V activity.
 - ✓ To agree the scope that IV&V evaluate.
- Strategy Planner → IV&V program leader
 - ✓ To confirm that he plan the IV&V strategy that he put together in utilizing knowledge of the past IV&V activities, specification information.
- Strategy Planner → Evaluation worker
 - ✓ To explain the IV&V strategy why "the judgment items" in the evidence should be evaluated.

■ The Completion Standard(extract):

- The strategy limiting the confirmation scope of the IV&V activity. (reflection of IV&V knowledge)
- Specification information be reflected as for the context.
- End sub-goal to be the same as a judgment item of the evidence.

Set up the evaluation axis of review the GSN

Policy of GSN review (extract)

- The scope and attribution of evaluation are appropriate.
- Re-utility is high.
- Logicality is high.
- Coverage is high.
- Easy to understand.
- It is possible to correspond with the defect factor.
- The evaluation methods and criteria are appropriate.

Build IV&V original strategy by the past defect information

No oversight or error in software's state transition

Focus on conditional
branch of state transition

No error of transitional
condition

No oversight of
transitional condition

Based on defect information,
expand the IV&V strategy

No error of ending
condition of state
transition

No oversight of ending
condition of state
transition

Limit the scope defined
failure process by
operational scenario

Focus on
operational scenario
the time for failure

...

Integrate software's
requirement that transitional
condition of state transition the
time for failure in operational
scenario

Integrity analysis results of
operational scenario and
software requirement

Introduction effects of IV&V case (1/2)

Improvement of
IV&V demand

Improvement of
IV&V value

Maintenance of
IV&V quality

- Improvement of interpretability to stakeholders
 - IV&V original evaluation contents, different from verification by developer, are understood to stakeholders, and IV&V activity can be more effectively.
 - IV&V can satisfy the new demand from stakeholders.
- Visualization of valuable knowledge in IV&V
 - Knowledge necessary for risk-based IV&V was realized and IV&V get to be able to utilize defect information and results of the past IV&V activities concretely.
- Ensure IV&V activity's constant quality
 - Evaluation contents are realized at the time of IV&V planning, and evaluation results don't depend on the ability of the IV&V engineer.
 - The division system of labor to assign the work of high difficulty to IV&V expert engineer was established.

Introduction effects of IV&V case (2/2)

Work
Results

Visualization of
Strategy

Application of
the Past Data
(Defects, IV&V results)

Direct
Effects

Activation of
Discussion

Take Shape of
Knowledge

Promotion of
Stakeholder's
Understanding

Ripple
Effects

Promotion of
Technique
inheritance

Establishment of
the Division System
of Labor

Improvement of
Engineer's
Motivation

Consideration of
New Verification
Strategies

Accumulation of
Data for
Investigation

Penetration of
Stakeholder's
Perspective to Engineer

Application

- Accumulated GSN are more than 100 per year.
- Some methods is necessary to provide us to access accurately and speedy to each GSN.

Quality

- More many worker will prepare GSN.
- Need to baseline about basic strategy and more.

Expression

- Opportunities to explain IV&V strategy to more stakeholders will increase.
- It is necessary to tailor the GSN to the purpose of explanation.

Summary

- Change of IV&V NEEDS
- New IV&V Value Concept
- Introduce IV&V case Utilizing GSN for Issues of IV&V solving

- Effects of IV&V case
 - Improvement of Demand and Value of IV&V for Stakeholders
 - Maintenance of IV&V Quality
 - And Ripple Effects

- Future Work
 - Application
 - Some methods is necessary to provide us to access accurately and speedy to each GSN
 - Quality
 - Need to baseline about basic strategy and more
 - Expression
 - It is necessary to tailor the GSN to the purpose of explanation

- Discussion of IV&V strategies
- Application of the past IV&V results

Sharing and Application of Knowledge

Maintenance and improvement of IV&V quality (evaluation accuracy)

Visualization by GSN

Improvement of IV&V value (originality of strategy)

Improvement of IV&V demand

Building the Platform for IV&V Activities

Expansion to the New Domain

- Development of original evaluation technique by analyzing the data (IV&V strategies and results)
- The best arrangement of IV&V engineer

- Separation of domain knowledge and IV&V knowledge
- Explanation of IV&V effect to the new development project

