INTEGRATED DYNAMIC PLANNING (IDP)

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Keywords: Dynamic, Wire Harness, DSM

1 ABSTRACT

The Integrated Dynamic Planning (IDP) concept, using robust matrix design & analysis methods, within an adaptive product development process (APDP) [1], is emerging as an improved product / project management approach to better visualize and manage the uncertainty in the early stages of complex product development lifecycles. In these early stages, the lifecycle of a wire harness assembly for a complex automotive or aerospace application involves more unknowns, due in part to the typical lag with the development of other 'hard parts' (i.e. structure, hydraulics, etc.) of the vehicle system. This introduces significant quantities of proposed functional and spatial engineering changes that need to assessed in the most efficient way possible.

The IDP concept, as abstractly represented in Figure 1, is the concurrent interaction of 4 major architecture perspectives, namely, A1) Specify & Design Product Architectures, A2) Design Organization Architecture, A3) Analyze Schedule Architecture, and A4) Integrate & Review Dynamic Results. Three of these perspectives, (A1, A2, and A4) feature the use of structured matrix design and analysis methods, which are necessary to understand the static structural information dependencies in a project. The dynamic aspects of this IDP approach, is represented in the A4 perspective, where the APDP uses project execution metrics to determine what set of pre-populated set of activities with assigned activity modes (quick, simulation, thorough), best represents the path to reaching the more desirable project metrics (technical performance measures (TPM), cost, schedule)..

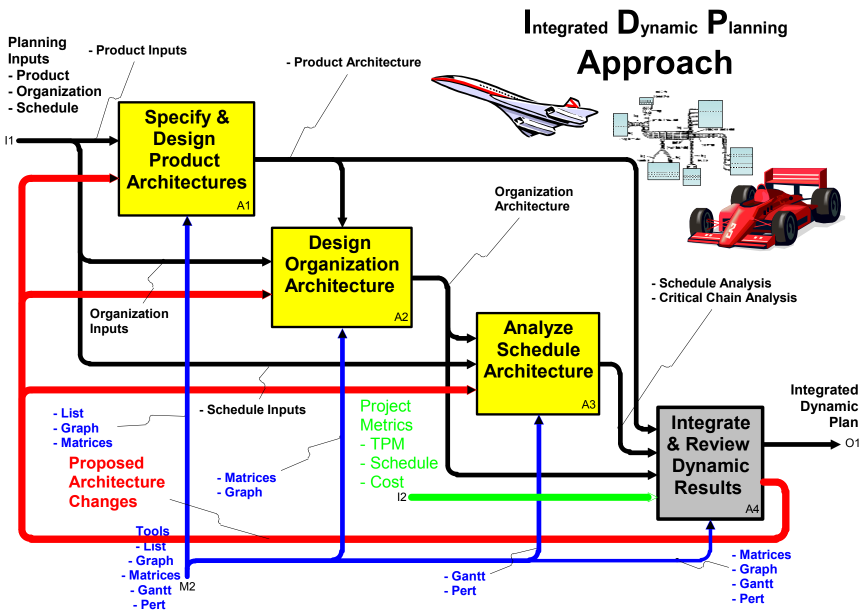

Figure 1. IDP Architecture Perspectives

The inherent dynamic and cyclical nature of the wire harness assembly development process appears to be a natural fit for IDP. The creation of multiple product / project execution scenarios based on proposed engineering-initiated or production changes, and the ability to quickly analyze and visualize aggregated matrix views using the Multi Domain Matrix (MDM) [2] design & analysis of Dependency Structure Matrices (DSM) [3,4] and Domain Mapping Matrices (DMM) [2], is desired. This capability, within the APDP, significantly increases the ability to rapidly redetermine the optimum outcome as new discoveries are made during the execution of the plan. Simply stated, IDP is an approach that 'visualizes' and 'designs' more successful product / project changes and dynamic plans, using integrated product, organization, and schedule architectures, and supports the need for **quickly** updating plans where high levels of uncertainty exists.

These planning interdependencies have been considered too complex – beyond the abilities of present-day product / project management methods and tools. With the advent of 4 new capabilities – the MDM, APDP, DSM and *Critical Chain Project Management* (CCPM) [5], those interdependencies, both known and unknown, can be more easily managed. Our proposed integration of these new capabilities, as illustrated in Figure 2, are principal enablers of the IDP approach.

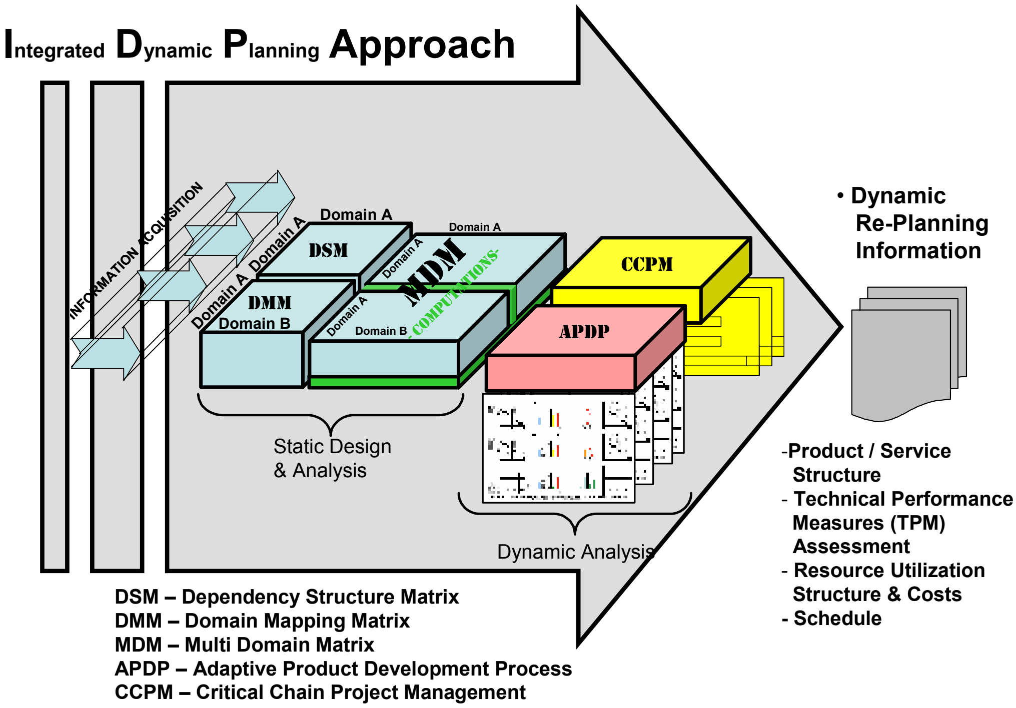

Figure 2. IDP Enabling Methods

Project schedules associated with typical engineering-initiated change plans have constraints and precedents. Critical path analysis is commonly used to address these issues. But critical path analyses are inadequate to clarify the necessary breadth of dependencies, changes, resource conflicts, and rework. It often misleads and confuses our management efforts. It cannot effectively handle iteration (a fundamental characteristic of product design). Further, it assumes that we can shuffle resources freely – that skilled persons are available for the asking. This is never the case.

So how do we handle product design changes and the associated replanning and scheduling in a dynamic environment? By more simply visualizing and analyzing the complex dependency structure required by information in the combined product, organization, and schedule perspectives, we can make decisions more wisely. Not keeping good track of information dependencies, and whether they are being satisfied, causes unnecessary project risks, overruns, and failure to meet requirements. As quickly as events or new ideas occur, projects can be managed from where they are rather than from where they were expected to be. (Out of scope for this discussion, though having significant impact to the cyclical product development environment, are the constraining product development tools and market architectures.)

In the application of this IDP approach to the development of a complex automotive or aerospace wire harness assembly, we are looking at the integration of 5 principal domains, namely 1) product, 2) people, 3) documents, 4) process, and 5) milestones. Each of these domains have their respective descriptions as collected from subject matter experts, which as illustrated in Figure 5, produced 11 matrices (4 DSMs, 7 DMMs) of a complete set of 16 within a typical MDM. The analyses of the designed MDM, created derived DSMs which represented the validation of the information structure from numerous combined perspectives.

This MDM analysis is a required prerequisite for the use of the APDP approach, as summarized in Figure 4. In the selected change scenario, which was based on functional tests performed on an installed wire harness assembly, Five of the 16 tasks were selected based on their quantitative Technical Performance Measures (TPM) outputs, then a superset of sequenced activities based on their respective modes (quick, simulation, thorough), gives the decision makers a more visual and executable plan that would better meet their overall project objectives.

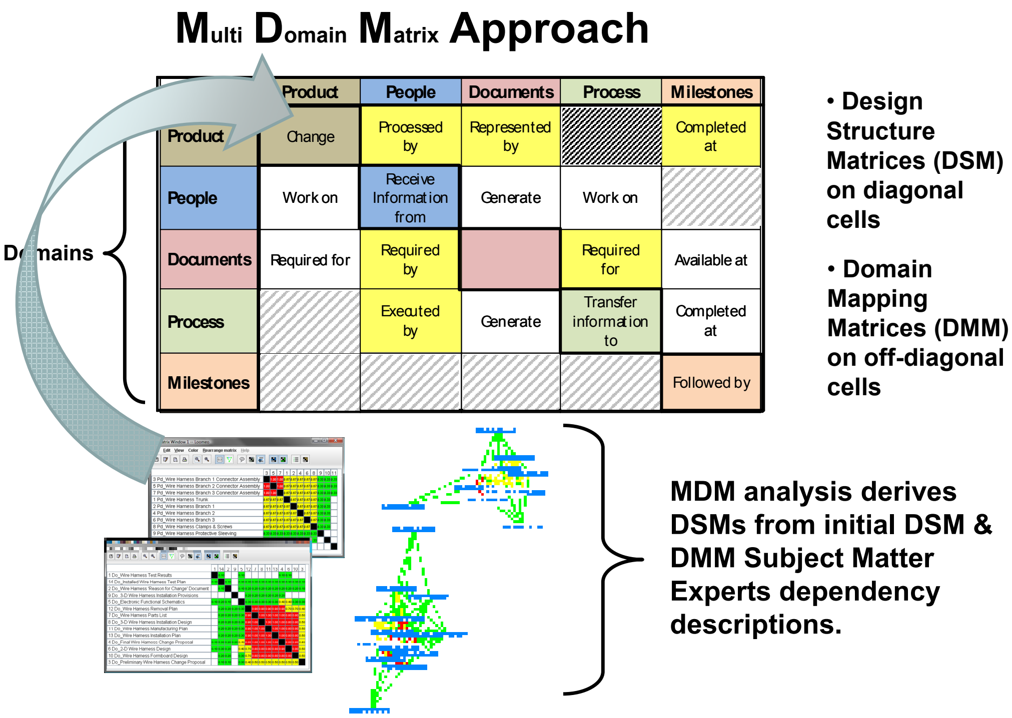

Figure 3. Wire Harness Assembly MDM Design & Analysis

Identifying an integration role for *ad hoc* or established product development teams, using powerful tools for visualization and analysis of plans that illuminate the risks to meeting the deliverables, schedule, resource usage, and cost goals, is desired. The ability to gauge the effects of original proposals, or changes, at any level of abstraction and at any project phase represents the goals of the IDP concept. Based upon independent and related studies, we believe IDP shows great promise for the design & execution of better dynamic plans in a developmental environment.

2 REFERENCES

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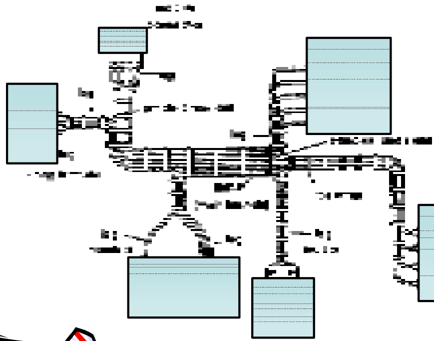
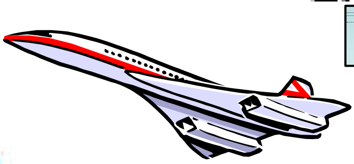
10TH INTERNATIONAL DSM CONFERENCE

Integrated Dynamic Planning (IDP)

Mike Stowe, Tyson Browning, Maik Maurer





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- **Proposed IDP Approach**
- **Wire Harness "Change Scenario"**
- **Principal IDP Approach Mechanisms**
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  - **Static Analysis (MDM, DSMs)**
  - **Dynamic Analysis (APDP, Critical Chain)**
- **Conclusions**

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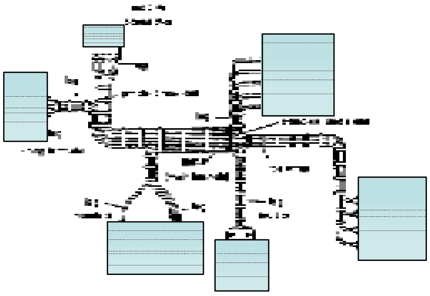
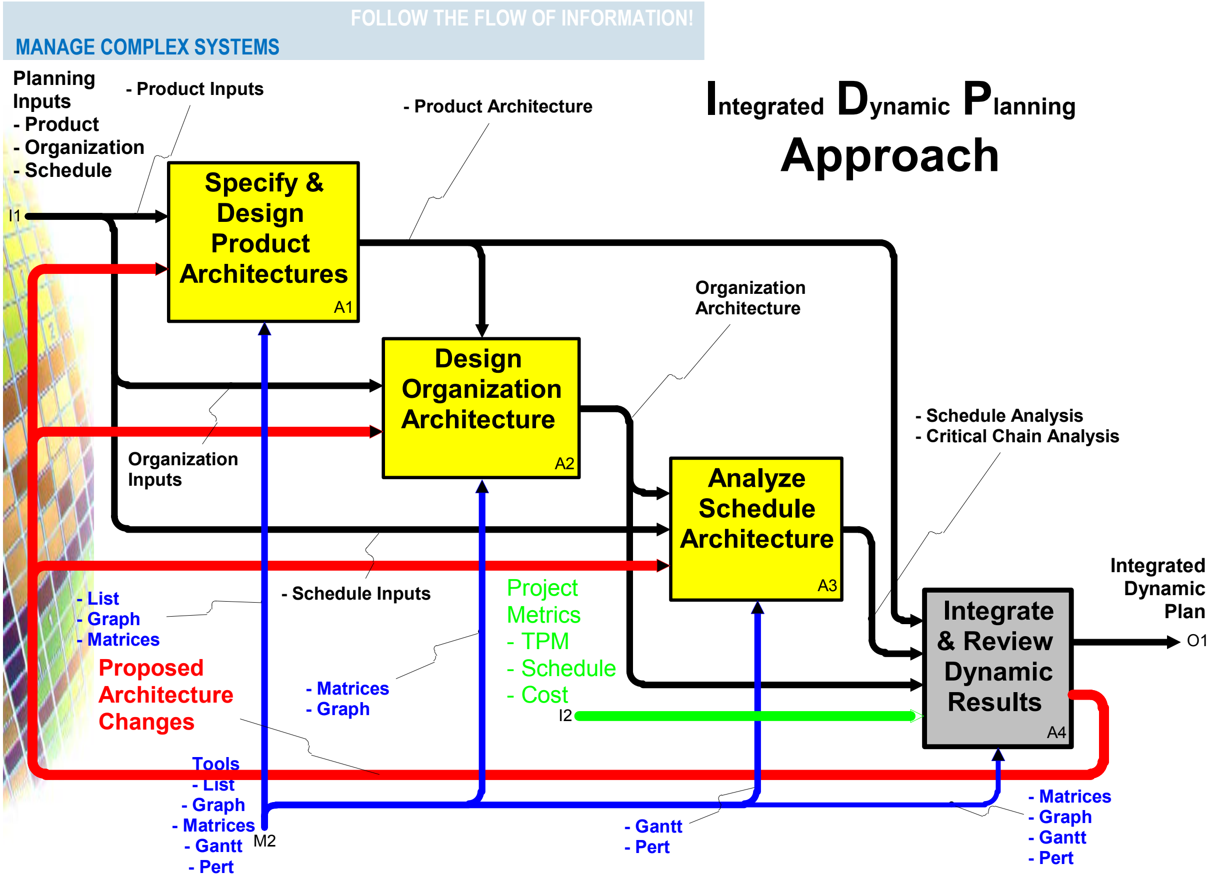
Motivating Hypothesis

- Wire harness designs, mature significantly later than a new vehicle structure in complex product development programs.



- Can the use of…
  - Dependency matrices (MDM, DSM, DMM)
  - Adaptive product development process (APDP),
- ..improve the planning & execution of functional changes discovered in installed wire harness assemblies?

Managing Complexity ?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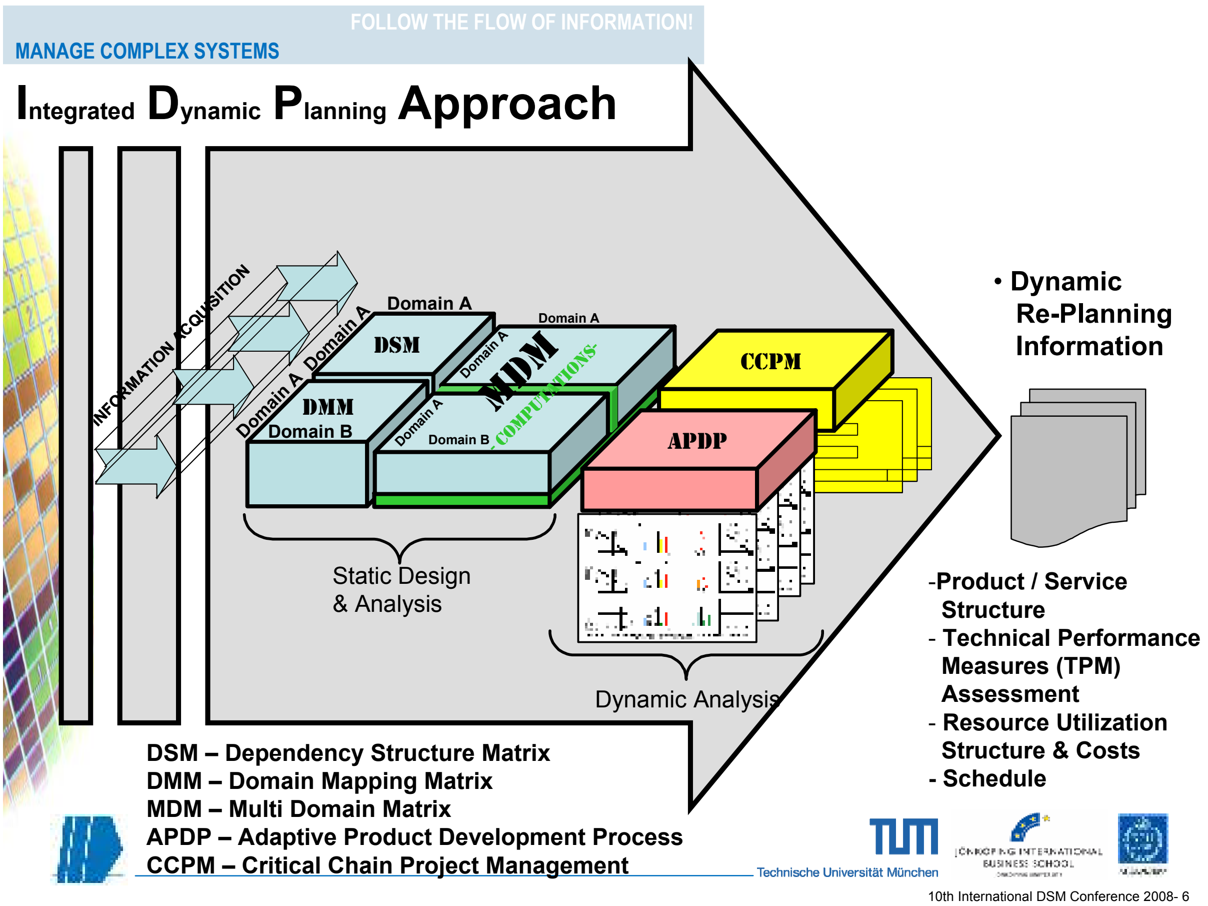
Integrated Dynamic Planning Approach
Planning Inputs
- Product
- Organization
- Schedule
- Product Inputs
- Product Architecture
I1
Specify & Design Product Architectures
A1
Design Organization Architecture
A2
Organization Architecture
Organization Inputs
Analyze Schedule Architecture
A3
- Schedule Analysis
- Critical Chain Analysis
Integrate & Review Dynamic Results
A4
Integrated Dynamic Plan
O1
- Schedule Inputs
- List
- Graph
- Matrices
Proposed Architecture Changes
- Matrices
- Graph
Project Metrics
- TPM
- Schedule
- Cost
I2
Tools
- List
- Graph
- Matrices
- Gantt
- Pert
M2
- Gantt
- Pert
- Matrices
- Graph
- Gantt
- Pert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Integrated Dynamic Planning Approach
INFORMATION ACQUISITION
Domain A
DSM
Domain A
Domain A
MDM
COMPUTATIONS
DMM
Domain B
Domain A
Domain B
CCPM
APDP
Static Design & Analysis
Dynamic Analysis
• Dynamic Re-Planning Information
-Product / Service Structure
- Technical Performance Measures (TPM) Assessment
- Resource Utilization Structure & Costs
- Schedule
DSM – Dependency Structure Matrix
DMM – Domain Mapping Matrix
MDM – Multi Domain Matrix
APDP – Adaptive Product Development Process
CCPM – Critical Chain Project Management
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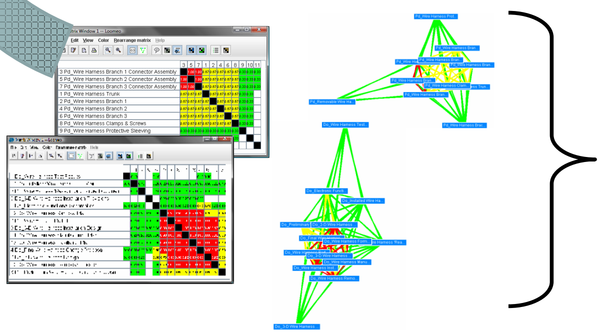
Multi Domain Matrix Approach

Domains

	Product	People	Documents	Process	Milestones
Product	Change	Processed by	Represented by		Completed at
People	Work on	Receive Information from	Generate	Work on	
Documents	Required for	Required by		Required for	Available at
Process		Executed by	Generate	Transfer information to	Completed at
Milestones					Followed by

- **Design Structure Matrices (DSM) on diagonal cells**
- **Domain Mapping Matrices (DMM) on off-diagonal cells**



MDM analysis derives DSMs from initial DSM & DMM Subject Matter Experts dependency descriptions.

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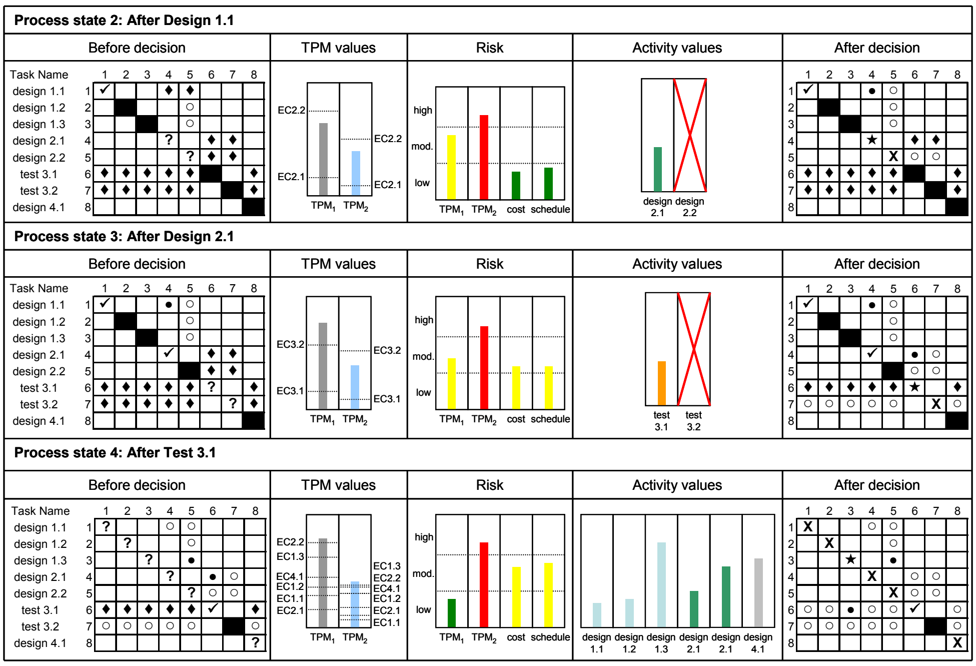
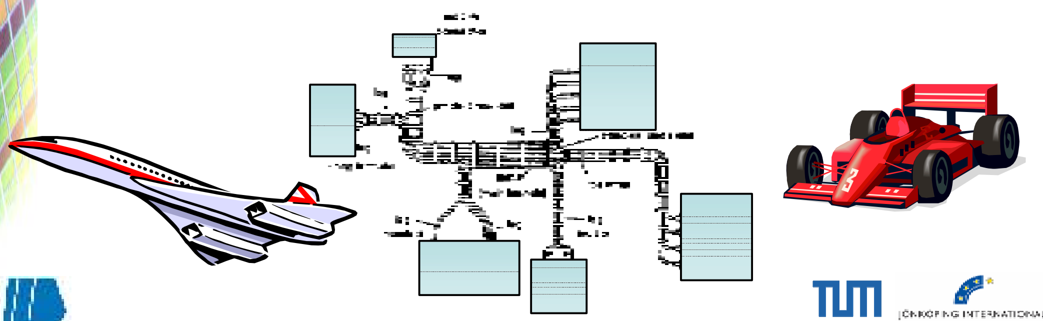
Adaptive Product Development Process Approach



● - active relation; ○ - inactive relation; ♦ - contingent relation; ✓ – finished activity; ? – potential activity; ★ - selected activity; X – inactive activity;
EC – entry criteria, TPM – technical performance measure

Wire Harness Change Scenario

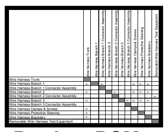
➢ **During final systems checkout, an installed wire harness was observed to be a contributor to unacceptable signal loss between a cluster of electronic equipment. How can the change plan be efficiently developed and executed to remedy this situation, given the unknowns that may occur anywhere in the lifecycle of this change?**



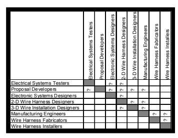
Wire Harness MDM (4 DSMs & 7 DMMs) Design

(11 of 16 matrices used in this demonstration)

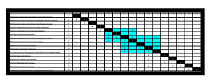
	Product	People	Documents	Process	Milestones
Product	Change	Processed by	Represented by		Completed at
People	Work on	Receive Information from	Generate	Work on	
Documents	Required for	Required by		Required for	Available at
Process		Executed by	Generate	Transfer information to	Completed at
Milestones					Followed by



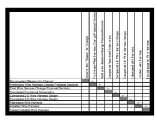
• **Product DSM**



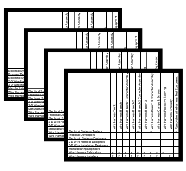
•**People DSM**



•**Process DSM**



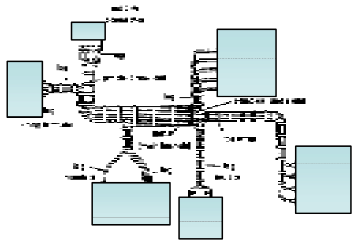
•**Milestones DSM**

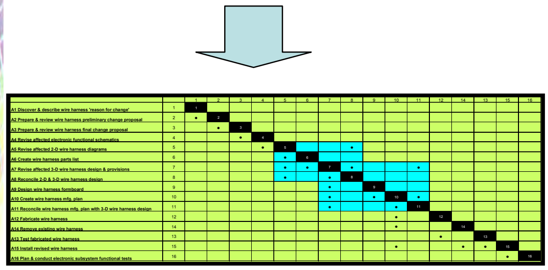


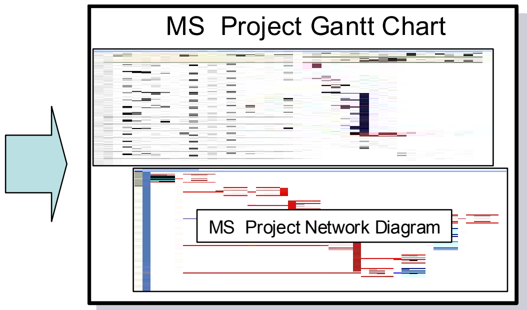
- **People / Product DMM**
- **People / Documents DMM**
- **People / Process DMM**
- **Documents / Product DMM**
- **Documents / Milestones DMM**
- **Process / Documents DMM**
- **Process / Milestones DMM**

MDM – Product & Process DSMs

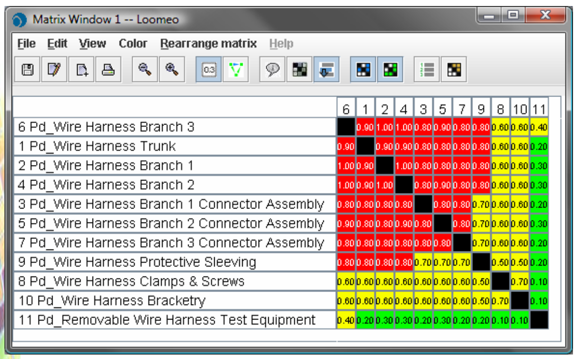
	Wire Harness Trunk	Wire Harness Branch 1	Wire Harness Branch 1 Connector Assembly	Wire Harness Branch 2	Wire Harness Branch 2 Connector Assembly	Wire Harness Branch 3	Wire Harness Branch 3 Connector Assembly	Wire Harness Clamps & Screws	Wire Harness Protective Sleeving	Wire Harness Bracketry	Removable Wire Harness Test Equipment
Wire Harness Trunk											
Wire Harness Branch 1	?		?					?	?	?	
Wire Harness Branch 1 Connector Assembly											
Wire Harness Branch 2	?				?			?	?	?	
Wire Harness Branch 2 Connector Assembly											?
Wire Harness Branch 3	?						?	?	?	?	
Wire Harness Branch 3 Connector Assembly											
Wire Harness Clamps & Screws	?										
Wire Harness Protective Sleeving	?										
Wire Harness Bracketry	?										
Removable Wire Harness Test Equipment											



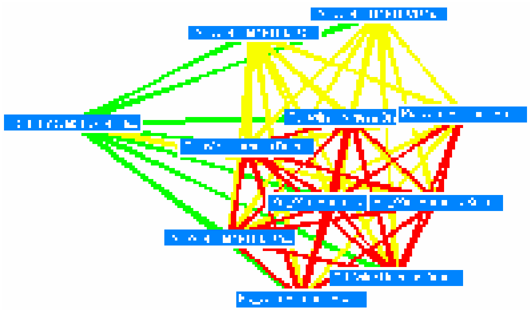




MDM – Static Analysis

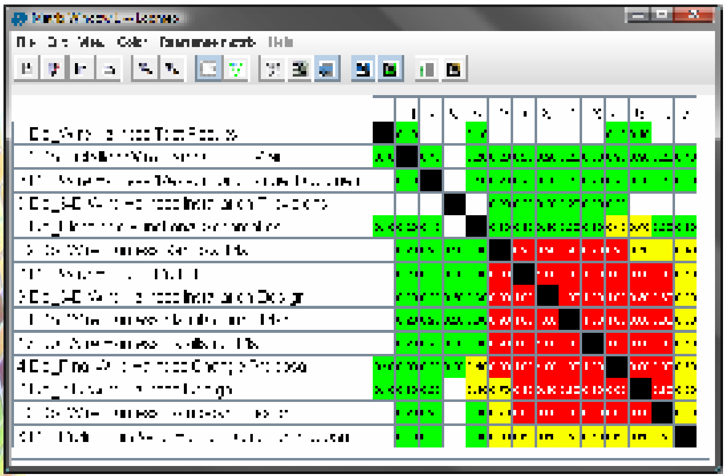


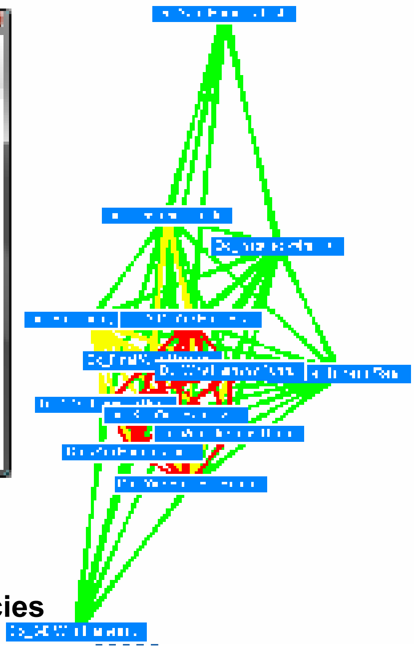
	6	1	2	4	3	5	7	9	8	10	11
6 Pd_Wire Harness Branch 3		0.90	1.00	1.00	0.80	0.90	0.80	0.80	0.60	0.60	0.40
1 Pd_Wire Harness Trunk	0.90		0.90	0.90	0.80	0.80	0.80	0.80	0.60	0.60	0.20
2 Pd_Wire Harness Branch 1	1.00	0.90		1.00	0.80	0.80	0.80	0.80	0.60	0.60	0.30
4 Pd_Wire Harness Branch 2	1.00	0.90	1.00		0.80	0.90	0.80	0.80	0.60	0.60	0.30
3 Pd_Wire Harness Branch 1 Connector Assembly	0.80	0.80	0.80	0.80		0.80	0.80	0.70	0.60	0.60	0.20
5 Pd_Wire Harness Branch 2 Connector Assembly	0.90	0.80	0.80	0.90	0.80		0.80	0.70	0.60	0.60	0.30
7 Pd_Wire Harness Branch 3 Connector Assembly	0.80	0.80	0.80	0.80	0.80	0.80		0.70	0.60	0.60	0.20
9 Pd_Wire Harness Protective Sleeving	0.80	0.80	0.80	0.80	0.70	0.70	0.70		0.50	0.50	0.20
8 Pd_Wire Harness Clamps & Screws	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.50		0.70	0.10
10 Pd_Wire Harness Bracketry	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.50	0.70		0.10
11 Pd_Removable Wire Harness Test Equipment	0.40	0.20	0.30	0.30	0.20	0.30	0.20	0.20	0.10	0.10	



- **Product components get linked because they require same data**
- **This resulting DSM validated the 3 functional groupings in the wire harness assembly product structure.**

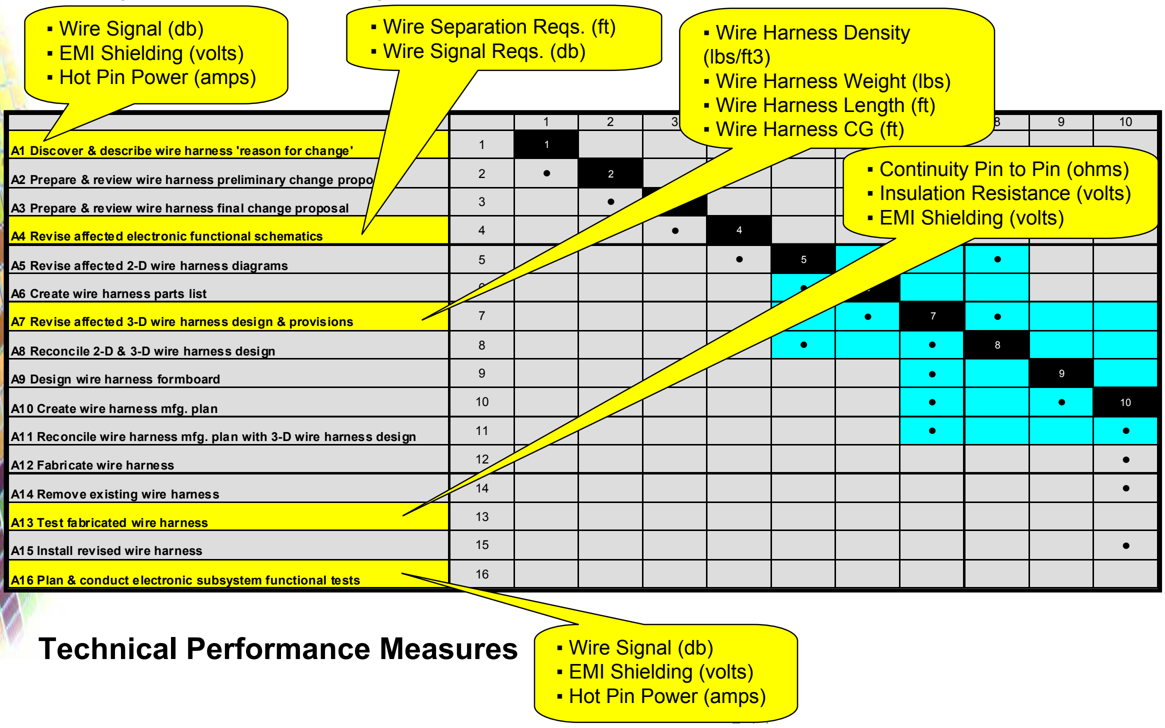
MDM – Static Analysis…(cont)





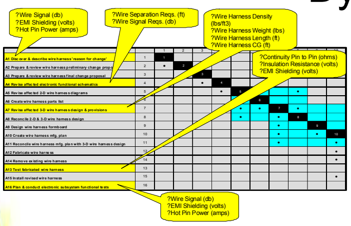
- Data get linked because they are required for the same product.
- This derived DSM validates the dependencies of the documents based on the required information flow.

Dynamic Analysis (Adaptive Product Development Process)



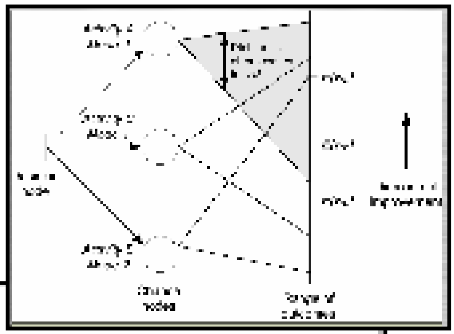
Technical Performance Measures

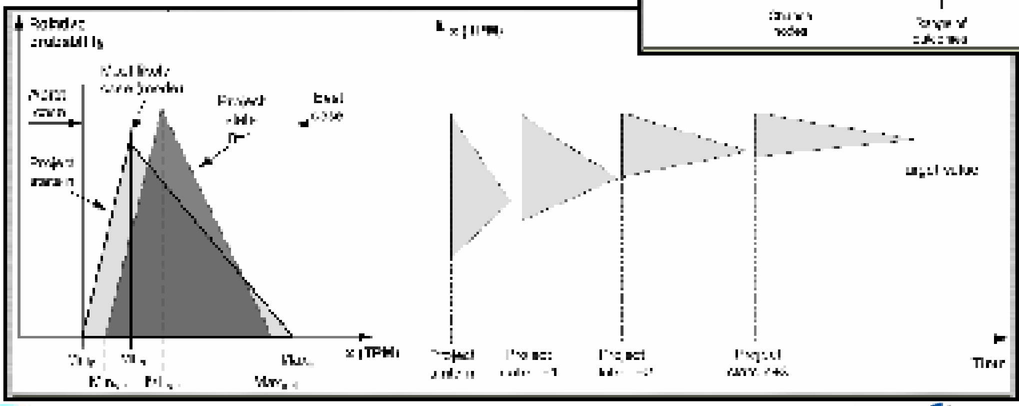
Dynamic Analysis…. (cont)



Activity Modes

1. **Quick Mode**
2. **Simulation Mode**
3. **Thorough Mode**





Conclusions

- **The MDM analysis of the wire harness change scenario was necessary to validate the proposed corrective action to improve the design.**
- **The APDP approach provided the superset of activities in selected modes (quick, simulation, thorough) based on the measurements collected and analyzed for the particular change scenario.**
- **The components of MDM & APDP, are necessary mechanisms to enable the concurrent execution of the following 4 IDP sub processes;**
  - **Specify & design product & project architectures**
  - **Design & analyze process architecture dependencies**
  - **Perform schedule & critical path analyses**
  - **Integration & review of combined results**