DeMAID - A Software Tool for

Analyzing and Optimizing the DSM

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The Design Manager's Aid for Intelligent Decomposition, better known as DeMAID, is a knowledge-based software tool for analyzing and optimizing the design structure matrix. Since the initial release of DeMAID in 1989, numerous enhancements have been made to aid in reducing the time and cost of the design cycle. These enhancements include determining which processes can be executed in parallel, decomposing complex design projects, and tracing the effects of design changes. A genetic algorithm has been added to rapidly examine many combinations of process ordering within a circuit, and to determine the optimum ordering based on time, cost, and iteration requirements. An aerospace company estimated that the design cycle can be reduced by as much as fifty percent using tools such as DeMAID to gain a better understanding of the process flow with the design structure matrix.

To further aid in reducing the time and cost of multidisciplinary design projects, new software tools such as frameworks for multidisciplinary computational environments have been developed. An examination of current frameworks reveals weaknesses in various areas, such as sequencing, displaying, monitoring, and controlling the design process. Using a web browser to view the design structure matrix and integrating the capability within an existing framework offers improvements in these areas of weakness.

DeMAID

(Design Manager's Aid for Intelligent Decomposition)

A Software Tool for Analyzing and Optimizing the DSM

(and Integration into a Web-Based Monitoring System)

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Outline

- **The problem**

- **DeMAID techniques for reducing design cycle time and cost which supports the second pillar (Revolutionary Technology Leaps) in NASA's Three Pillars to Success**

    Goal: Provide next-generation design tools and experimental aircraft to increase design cycle confidence and cut the development cycle time for aircraft in half.
    http://www.hq.nasa.gov/office/aero/

- **The DSM in a web-based monitoring system**
    Sequencing, monitoring, displaying, and controlling

- **Concluding remarks**

The Problem

In today's competitive environment, both industry and the government are under enormous pressure to reduce the time and cost of their design cycle.

One solution is process management

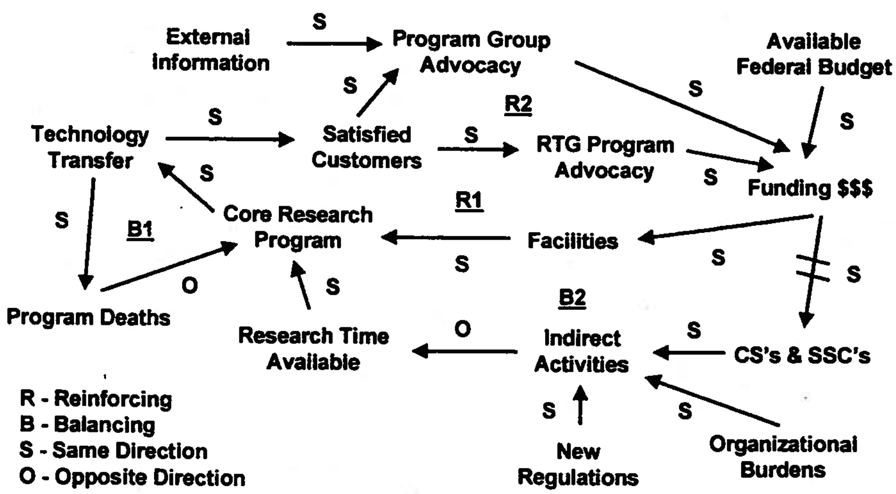
where

Output = Process (Input1, . . . , Inputn)

Time and cost associated with each process

Systems Thinking

Question: Why haven't we been able to sustain a core research program?

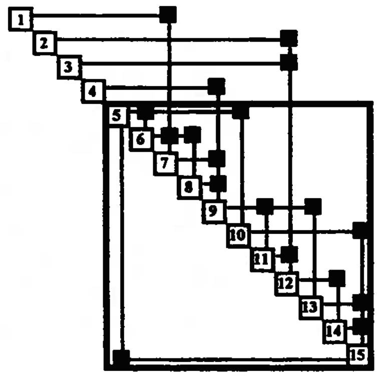


R - Reinforcing
B - Balancing
S - Same Direction
O - Opposite Direction

Case Study DSM
(Sustained Core Research)

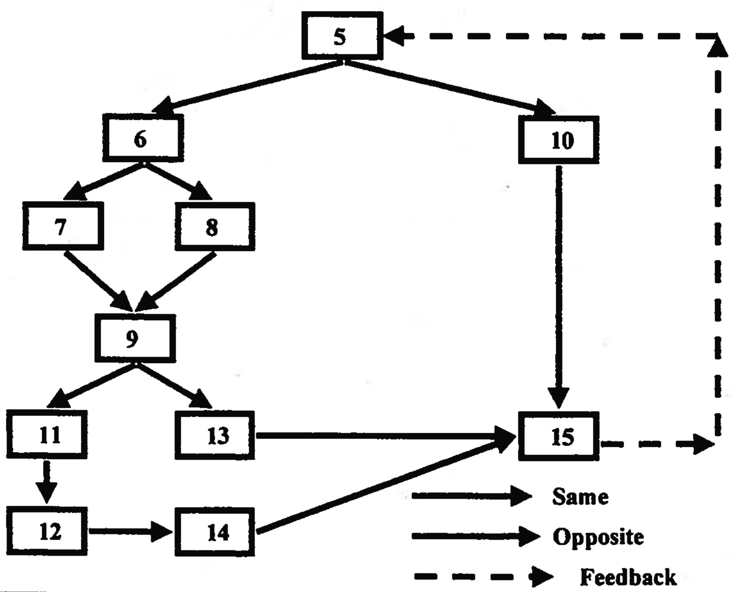
Processes

1 External Information
2 New Regulations
3 Organizational Burdens
4 Available Federal Budget
5 Technology Transfer
6 Satisfied Customers
7 Program Group Advocacy
8 RTG Group Advocacy
9 Funding $$$
10 Program Deaths
11 CS's and SSC's
12 Indirect Activity
13 Facilities
14 Research Time Available
15 Core Research

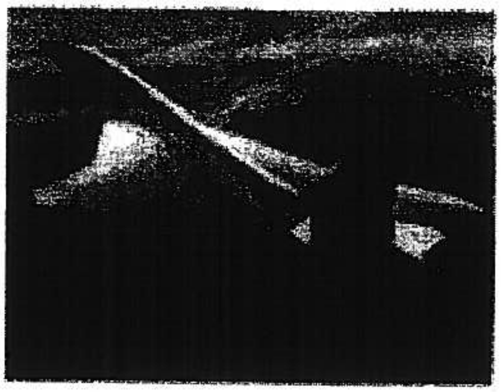


■ Same
■ Opposite

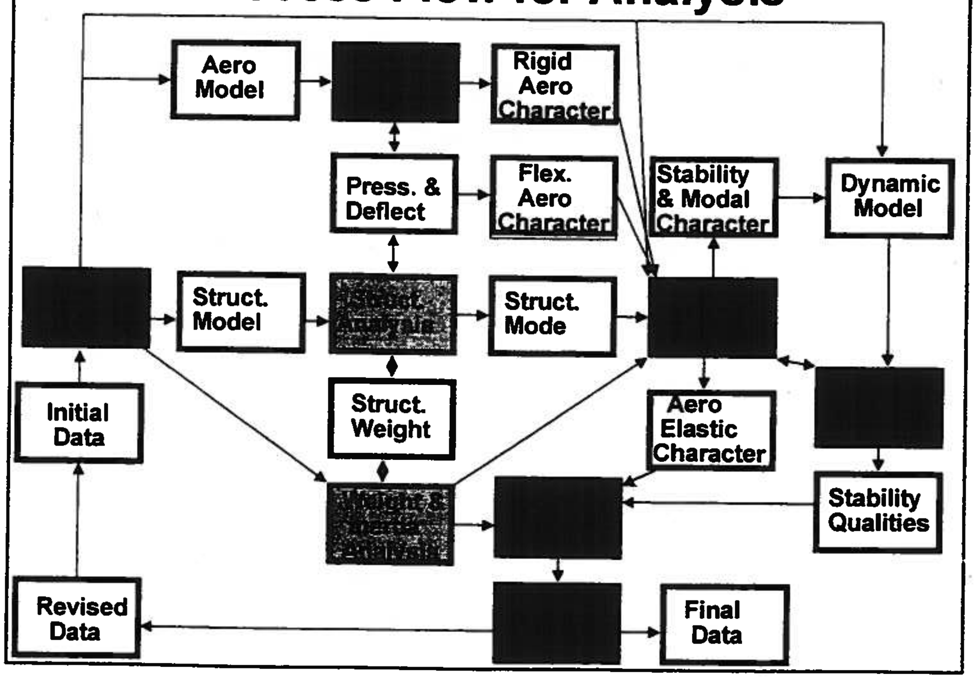
Case Study Decomposition
(Sustained Core Research)



Conceptual Design of an Aircraft

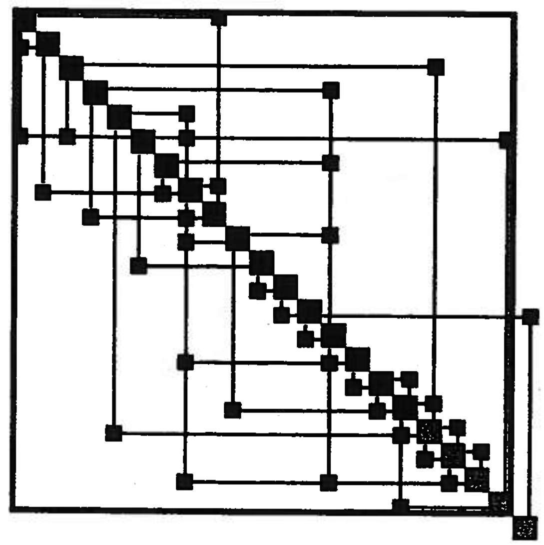


Process Flow for Analysis



Design Cycle Time and Cost

Process	Time	Cost
DYNMODL	30	30
STDMOCH	40	20
STRMODL	10	50
HANDQUL	10	50
STRMODE	10	50
GEOMDEV	50	10
AROSRVO	40	20
STRDYNA	50	10
CSVSANL	20	40
FAEROCH	20	40
INITDAT	40	20
RVSEDAT	30	30
MISPERF	30	30
VEHPERF	20	40
RAEROCH	30	30
AEROANL	20	40
PRESDEF	30	30
STRANAL	40	20
STRCTWT	50	10
WIANAL	40	20
AEROMDL	20	40
FINLDAT	20	40



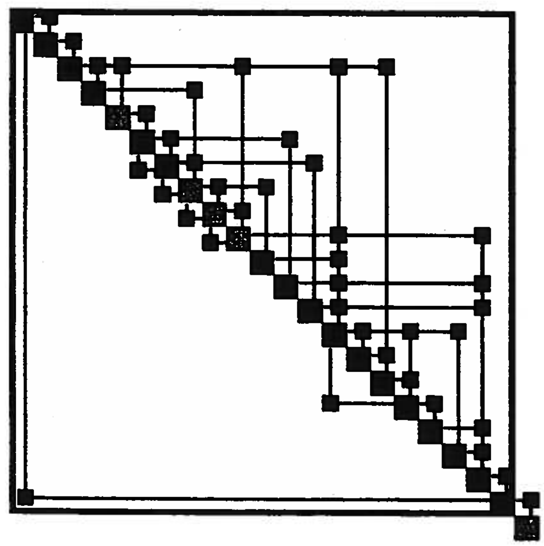
Time - 21,340 Cost - 19,640

Techniques in DeMAID for Reducing Design Cycle Time and Cost

- Optimum sequencing with a genetic algorithm
- Hierarchical decomposition
- Parallel processing within a circuit
- Rapid re-analysis

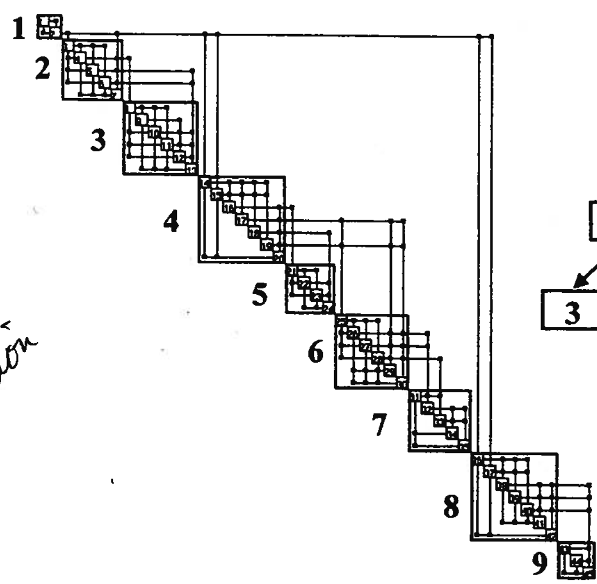
Reduced Design Cycle Time and Cost

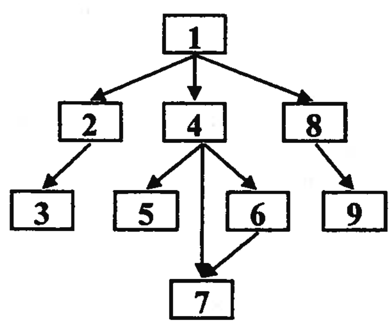
Process	Time	Cost
RVSEDAT	30	30
INITDAT	40	20
GEOMDEV	50	10
STRMODL	10	50
AEROMDL	20	40
AEROANL	20	40
PRESDEF	30	30
STRANAL	40	20
STRCTWT	50	10
WIANAL	40	20
STRMODE	10	50
RAEROCH	30	30
FAEROCH	20	40
STRDYNA	50	10
STDMOCH	40	20
DYNMODL	30	30
CSVSANL	20	40
HANDQUL	10	50
AROSRVO	40	20
VEHPERF	20	40
MISPERF	30	30
FINLDAT	20	40



Time from 21,340 to 3,800 **Cost from 19,640 to 3,220**

Hierarchical Decomposition





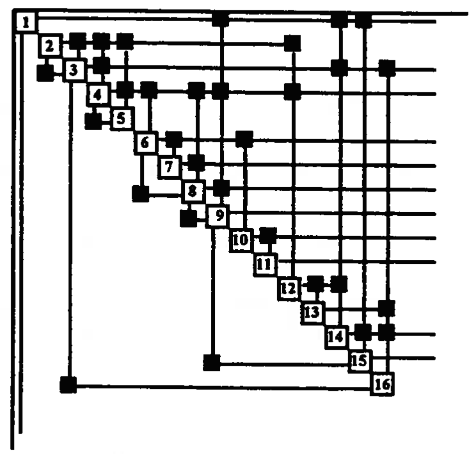
This is really an integration after a block diagonalization

Parallel Processes within a Circuit

(Partial DSM for MIT Brake Design Project by Black)

Processes

1 Airflow
2 Booster
3 Liningc1
4 Rotordi
5 Pedalme
6 Knuckle
7 Rotoren
8 Rotorwi
9 Rotorco
10 Drumenv
11 Drumbrk
12 Liningc2
13 Linepre
14 Tempera
15 Wheelde
16 Liningr



Parallel Processes

1 2

3

4

5 6 12

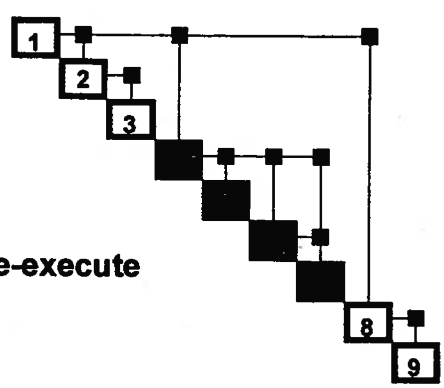
7 10 13 14

8 11 15 16

9

Rapid Re-Analysis

The effects of a change made in circuit 4.



Re-execute

The DSM and a Web-Based Monitoring System

Framework - A framework for multidisciplinary design optimization is defined as a hardware and software architecture that enables integration, execution, and communication among diverse disciplinary processes.

Context of This Activity

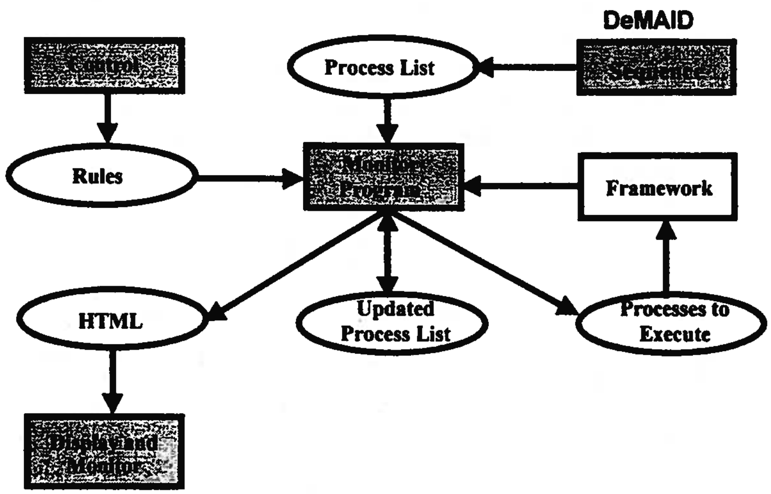
•In 1996, an in-house evaluation uncovered apparent weaknesses in existing frameworks at that time:
- Sequencing processes
- Displaying results
- Monitoring project flow
- Controlling process flow

•Purposes of this project:
- Explore how process management & Web technologies, integrated into an existing framework, might improve areas of weakness

•Examples of framework products

iSIGHT - Engineous	MDICE - CFD Research
POINTER - Synaps	IMAGE - Georgia Tech
OPTIMUS - LMS	DAKOTA - Sandia

Implementation with an Existing Framework



Monitor Program

The monitor program:

- •reads the list of processes created by DeMAID
- •read rules to determine which processes are ready for execution
- •creates a file of processes ready for execution and passes it to the framework
- •updates the status for the list of processes file
- •creates an HTML file to display the process flow on the Web in DSM format

Sequencing

Weakness

Existing frameworks typically
- did not optimize process sequence
- fixed the sequence to execute processes which is usually application dependent
- required significant labor to code sequence

Capability

For this approach, DeMAID (Design Manager's Aid for Intelligent Decomposition) applied as a pre-processor to determine optimum sequence
- Minimizes feedbacks
- Determines iterations
- Creates a list of processes and their couplings
- Makes process sequence application independent

Monitoring

Weakness

Existing frameworks did not allow project engineers to monitor the process flow.

Capability

•The DSM in HTML format used for monitoring process flow

•Colors indicate the status of both processes and coupling data

•Links to process web pages provide access to more detailed information and data for each process

•The DSM is automatically updated every few seconds to provide insight to the most current status

DSM for Test Problem in HTML Format

Links

Process Name	Process #	1	2	3	4	5	6	7	8	9
init	1	1								
movehist	2		2							
anal1	3									
anal2	4				4					
step	5					5				
deriv1	6						6			
deriv2	7									
gsenext	8								8	
optimizer	9									9

Processes - Diagonal
Turquoise - will not execute again
Yellow - waiting for data
Green - executing
Black - removed because no change in data

Coupling data - Off-diagonal
Blue - data is available
Red - data is not available
Gray - part of a circuit

everything below the diagonal begins as blue (since assumptions are available)

Displaying

Weakness

Existing frameworks did not allow easy access to data displays from different computers and geographic locations.

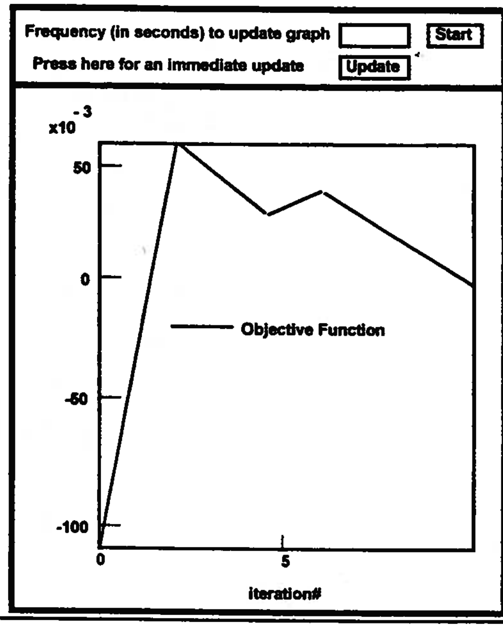
Capability

Java applets implemented to display both current and historical data and are invoked from the process web pages.

- Objective Function
- Design Variables
- Constraints Status

All of this information is readily available to anyone with access privileges to the web page.

Test Problem Objective Function History



Controlling

Weakness

Existing frameworks had a fixed process sequence where neither the process sequence nor the process detail could be changed.

Capability

•Rules used to determine processes ready for execution.

•Control options set with HTML forms and passed to the server program.
- Deactivate a process if the output from the process is not changing. The process may later be reactivated.
- Select from among several programs for the same process. For example, select an approximation or a full analysis (not yet implemented).

Concluding Remarks

- Design cycle time and cost can be reduced by analyzing and optimizing the sequence of design processes with DSM tools like DeMAID.

- The DSM appears to be ideally suited for web-based applications

- DeMAID is considered a mature piece of software and is available to US researchers at no cost.

- The Web-Based Monitoring System was done as a proof-of-concept activity.

Internet address for DeMAID details

http://fmad-www.larc.nasa.gov/mdob/users/rogers/Current_research/DeMAID.html