

Charting Multidisciplinary Team External Dynamics using a Systems Thinking Approach

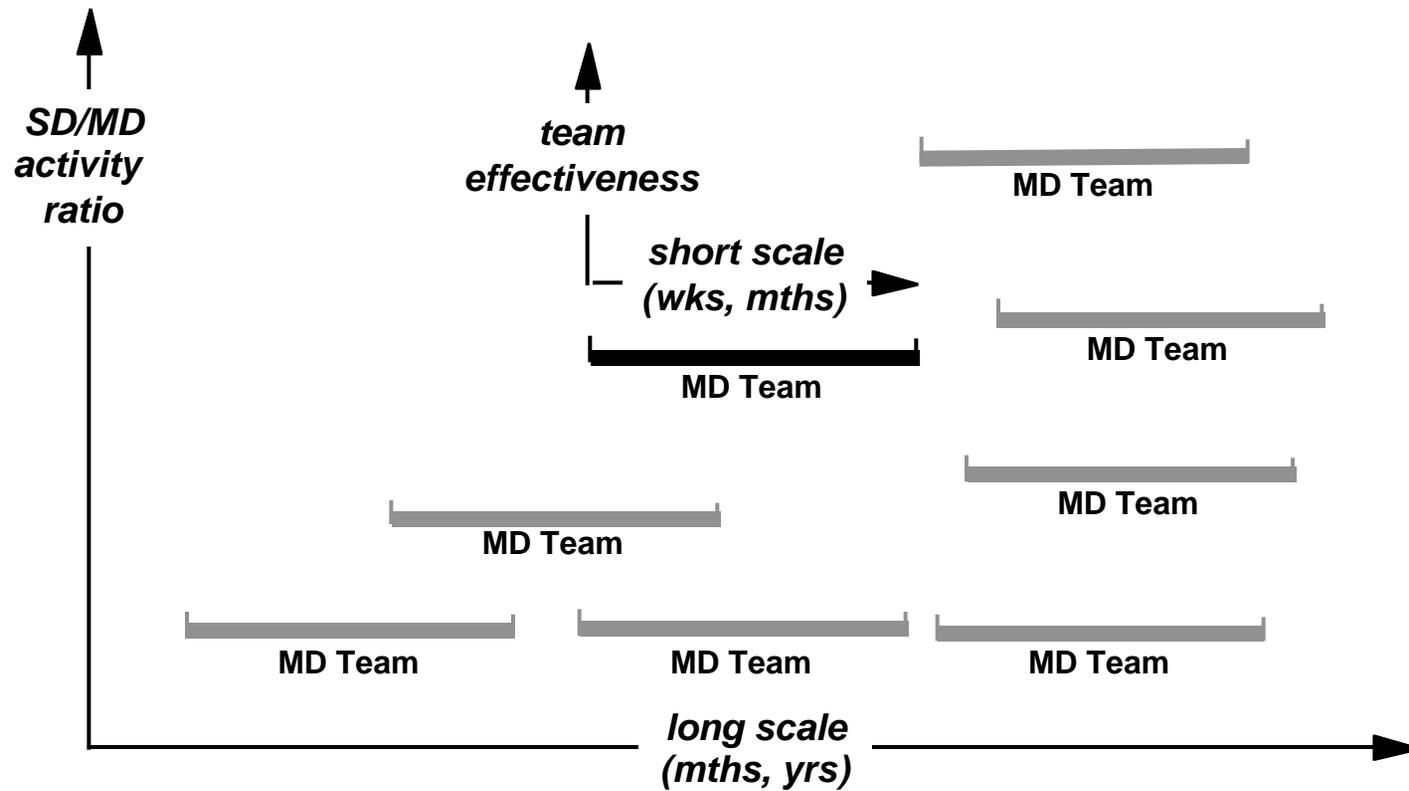
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Motivation

- In a functional organization, multidisciplinary (MD) research, developments, and applications depend on cross-functional teams made up of members from different organizational elements
- MD work success depend on the organization underlying the teams that carry it out
- › *Need to observe organizational dynamics to:*
 - analyze impact on MD development success
 - recommend organization that fosters strong MD contributions

External vs Internal Team Dynamics



Outline

- **Motivation**
- **Background on Target Organization**
- **System Thinking Introduced**
- **External Dynamic**
 - **Organizational Commitment**
 - **Individual Proficiency, Organizational Competency**
 - **Individual Affinity and Familiarity**
 - **Technical Maturation**
 - **Technical Maturation Gap**
- **Conclusions**

Background

LaRC R&D is organized as a *Functional Matrix*

- LaRC aeronautic R&D is conducted by the Research and Technology Group (RTG) which is organized along functional (disciplinary) lines
- LaRC R&D plan is devised by Program Offices (POs) with collaboration from planning teams of RTG members
- This is a *Functional Matrix*
 - POs oversee/coordinate projects across functional organizations
 - Line organizations (RTG) retain primary responsibility for their segments of the project

Background

LaRC Resources are expended either in SD or in MD work

- **With given resources, two kinds of activities can be carried out:**
 - **SD ((Single)Disciplinary) activities**
 - **MD (MultiDisciplinary) activities**

- **Program offices review and (re)define the R&D portfolio annually in a process that include:**
 - **proposal writing by RTG organizations**
 - **portfolio selection by teams led by Program Offices**

- › **The balance between SD and MD activities is set by the POs in the R&D portfolio selection process**

- › **Individual researchers as well as line management (RTG) retain a significant indirect control on the balance through their participation in the program office planning processes**

Background

Key Variable

- **The key variable in the analysis is the ratio between MD activities and SD activities**
- **LaRC operates in a fixed resource environment, therefore if the amount of MD activities is increased, the resources available for SD activities are decreased!**

Systems Thinking Introduction

- ***System Thinking*** is a formalism that aims at discovering the structure behind system dynamics, so that it can be understood and affected, if desired.
- **Key ingredients of system thinking models:**
 - variables
 - causal links between variables
 - loops link variables
 - archetypes
 - interventions
- **System Thinking dovetails with MDO** as it identifies, models and characterizes the interconnectedness of elements making up a system.

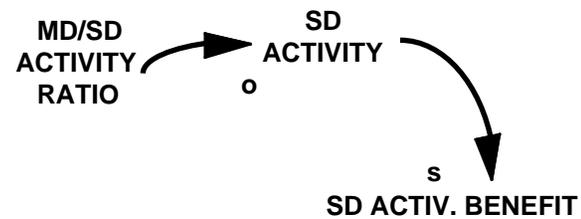
SD(MD) Activities

Build-up Organization Commitment



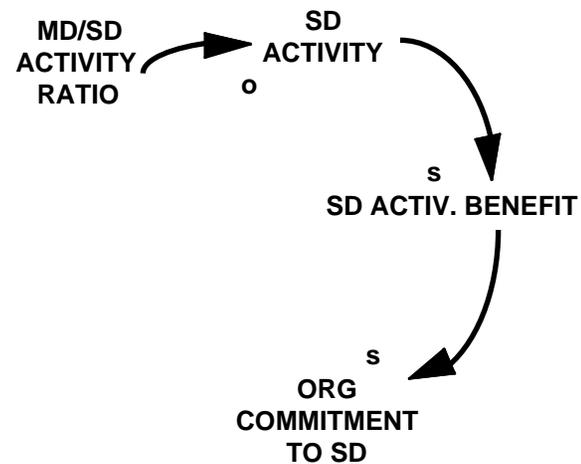
SD(MD) Activities

Build-up Organization Commitment (Cont.)



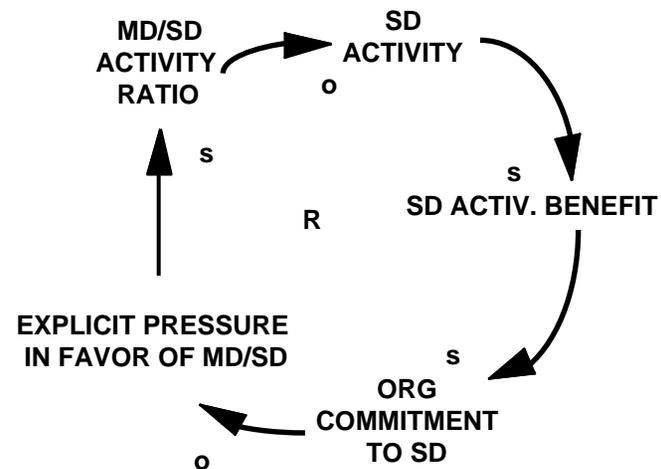
SD(MD) Activities

Build-up Organization Commitment (Cont.)



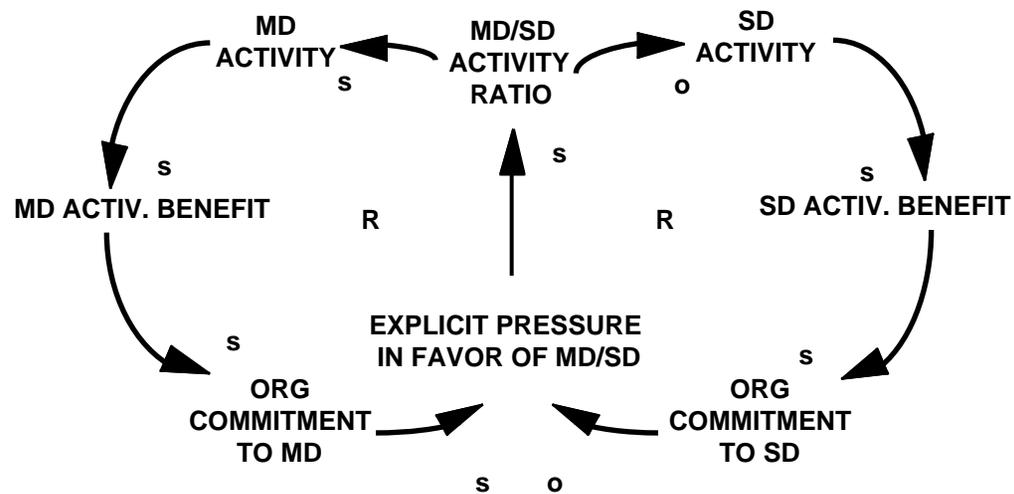
SD(MD) Activities

Build-up Organization Commitment (Cont.)



SD(MD) Activities

Build-up Organization Commitment (Cont.)



Key Archetype: Success to the Successful

- **Structure:**
 - Pair of reinforcing loops; one virtuous, the other vicious
- **Story:**
 - Two activities compete for a common limited resource
 - As SD activities' success increases, more resources are allocated to them, less resources are available for MD activities
 - With less resources, MD activities' success decreases and less resources are allocated to them
 - Key to the dynamics: resource allocation decision rule
- **Interventions:**
 - + Base resource allocation on potential/demonstrated success
 - + Look for overarching goal for SD and MD activities
 - Break the resource link, if warranted
 - Look for additional resources, if possible

SD(MD) Activities

Build-up Organization Commitment (Concl.)

- **Potential Interventions:**
 - Drive R&D portfolio selection with cross-functional goals
 - Use reliable system metrics to set MD/SD balance
 - Determine, document and advertise benefits from MD activities
 - Arbitrarily raise the MD/SD balance

Outline

Motivation

Background on the target organization

System Thinking Introduced

External Dynamic

Organizational Commitment

- **Individual Proficiency, Organizational Competency**
- **Individual Affinity and Familiarity**
- **Technical Maturation**
- **Technical Maturation Gap**

- **Conclusions**

Conclusions

How to Improve/Increase MD Developments

- **Individual Researcher**
 - develop effective development cost/system benefit metrics
 - predict/document benefit of MD solutions over SD solution
- **Functional Organization (RTG)**
 - foster generic MD developments
 - make SD developments MD-capable
 - create/maintain effective teams
- **Program Offices (POs)**
 - define cross-cutting program goals
 - use reliable development cost/system benefit metrics
 - artificially set MD/SD activity ratio

Additional Material

External Dynamics Stories

MD(SD) Activities Build-up Organization Commitment

- Story:
 - Increased MD activities result in increased MD benefits
 - MD benefits result in increased organization commitment for MD
 - Similar arguments can be developed for SD activities
 - However, initially low MD/SD ratio favors SD activities and results in more commitment in favor of SD activities
- Potential Interventions:
 - Drive R&D portfolio selection with cross-functional goals
 - Use reliable system metrics to set MD/SD balance
 - Determine, document and advertise benefits from MD activities
 - Arbitrarily raise the MD/SD balance, particularly at the outset

External Dynamics Stories

MD(SD) Activities Improve MD(SD) Proficiency, Organization Competency

- Story:
 - Increased experience in MD, increases individual proficiency, therefore improves activity cost and cost/benefit
 - Similar arguments can be developed for SD activities
 - However, initially low MD/SD ratio favors SD activities
 - Where aligned with core competency of organization (ie SD), proficiency is bound to increase organization commitment
 - However, same argument is not valid for MD activities
- Potential Interventions:
 - Boost MD education, track and hire people with MD education/ experience
 - Maintain a “structure” responsible for an MD core competency
 - maintain an integration competency area in each SD organization
 - implement an effective matrix organization

External Dynamics Stories

MD(SD) Activities Increase Affinity, Familiarity with MD(SD) Work

- Story:
 - Increased MD benefit increases researcher affinity for MD, as reinforced by personal satisfaction, rewards, and recognition
 - Increased MD work reinforces individual familiarity with MD
 - Affinity and Familiarity with MD increase pressure for MD
 - Similar arguments can be developed for SD activities
 - However, initially low MD/SD ratio favors SD activities
- Potential Interventions:
 - Recognize/reward MD work
 - Create/maintain effective teams
 - Recognize/reward teamwork

External Dynamics Stories

MD(SD) Activities Affect MD(SD) Technical Maturation, Cost/Benefit

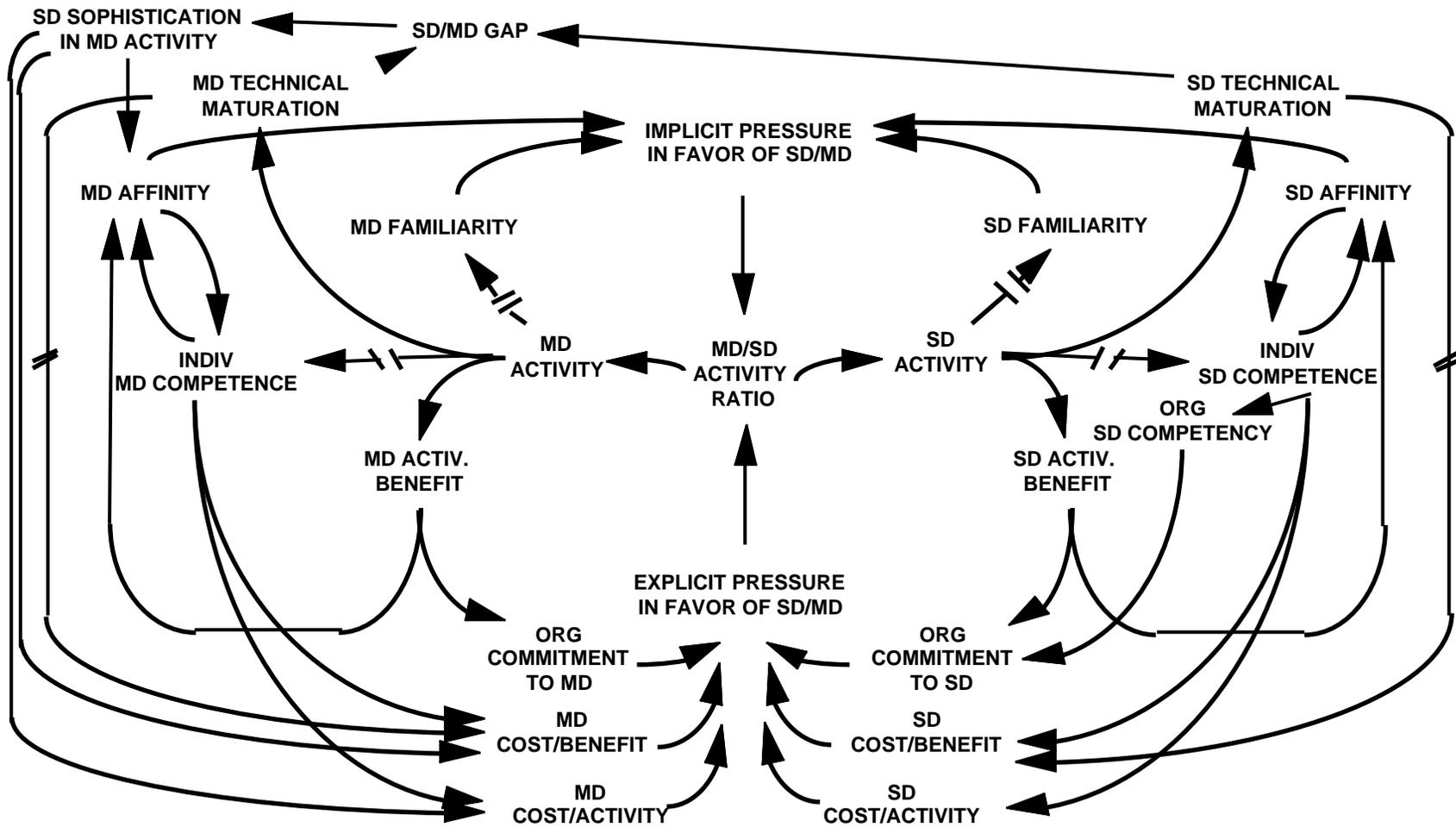
- Story:
 - Increased MD activities increase MD technology maturation
 - Eventually technology maturation increases MD cost/benefit ratio
 - Similar arguments can be developed for SD activities
 - However, proposed SD and MD activities are difficult to compare because of the lack of system development cost/benefit metrics
- Potential Interventions:
 - Develop system development cost/benefit metrics
 - Make calculation of benefit of MD over SD a requisite of MD activities

External Dynamics Stories

MD(SD) Technical Maturation Affects SD/MD Gap

- **Story:**
 - There is a maturation gap between SD capabilities and MD capabilities
 - SD activities increase SD technical maturation
 - SD technical maturation increases maturation gap
 - Contrary arguments can be developed for MD activities
 - **However**, increased maturation gap
 - reduces SD researcher affinity for MD
 - increases MD application cost
 - > decreases pressure for MD
- **Interventions:**
 - balance SD sophistication in MD work
 - > carry out generic MD developments
 - > make key SD methodologies MD-capable

Summary



Summary

Comments

- The diagram is mostly symmetric as it follows the success-to-the-successful archetype
- The only non symmetric elements are introduced by:
 - the lack of infrastructure responsible for MD activities
 - the tension existing between the SD state-of-the-art and the capacity for MD to accommodate it
- The lower part of the diagram deals with explicit decision making questions for which some metrics are available, the upper part deals with implicit issues, more difficult to quantify

Conclusions

On the use of the System Thinking Formalism

- **Provides systematic approach at examining organization dynamics**
 - identify variables, causal links, loops, *external factors, mental models*
 - determine archetype
 - extract possible interventions
- **Produces a model that predicts change in dynamics as internal or external conditions change**
- **Observations are strictly valid for target organization, but model contains many elements present in other R&D organizations**