Need to Know

Information, Knowledge & Decision Making

William B. Rouse

School of Industrial & Systems Engineering
Georgia Institute of Technology
Atlanta, Georgia 303302 USA
Overview

- Context of Decision Making
- Definitions of Information & Knowledge
- Information & Knowledge Requirements
- Types of Information & Knowledge
- Information & Knowledge Seeking & Use
- Three User Domains & Four Solutions
  - Research ➔ Online bibliographic databases
  - Design ➔ Design information systems
  - Management ➔ Strategic management tools
  - Management ➔ Online management services
- Implications for Information & Knowledge Support
Context of Decision Making

Our Focus

Management

Research <-> Design <-> Production <-> Sales <-> Support

B-to-B
ERP
MRP
Etc.

B-to-C
SFA
CRM
Etc.
Definitions: Info & Knowledge

- **Information**: An assembly of data in a comprehensive form capable of communication and use.

- **Knowledge**: Information evaluated and organized in the human mind so that it can be used purposefully.

- Information & Knowledge  ➔ I&K
I&K Requirements vs. Time

Long-Term
Next Qtr Or Later

Near-Term
This Week Or Month

Immediate
Today

Mandatory
Cannot Proceed Without It

Standard Practice
Everyone Uses It

Discretionary
Knowledge Value Must Be Clear

Our Focus
## Types of Information & Knowledge

<table>
<thead>
<tr>
<th>Type of I&amp;K</th>
<th>Research</th>
<th>Design</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of underlying phenomena</td>
<td>e.g., previous studies of phenomena of interest</td>
<td>e.g., compilation of data &amp; equations</td>
<td>e.g., company case studies &amp; lessons learned</td>
</tr>
<tr>
<td>Nature of critical issues &amp; tradeoffs</td>
<td>e.g., interactions among key variables</td>
<td>e.g., cost vs. performance tradeoffs</td>
<td>e.g., cross-company comparisons</td>
</tr>
<tr>
<td>Estimates &amp; projections of important variables</td>
<td>e.g., tabulations of properties</td>
<td>e.g., operating curves &amp; conditions</td>
<td>e.g., financial performance = function (R&amp;D investment)</td>
</tr>
<tr>
<td>Suggestions &amp; characteristics of alternatives</td>
<td>e.g., alternative theories of phenomena</td>
<td>e.g., alternative technologies &amp; processes</td>
<td>e.g., alternatives strategies &amp; tactics</td>
</tr>
<tr>
<td>Inputs to tradeoff analyses &amp; optimization</td>
<td>e.g., computational requirements</td>
<td>e.g., technology maturity, production learning curves</td>
<td>e.g., projections of risks &amp; returns of portfolio</td>
</tr>
<tr>
<td>Identity &amp; assessment of competitors</td>
<td>e.g., publications of competing investigators</td>
<td>e.g., competitors’ product characteristics</td>
<td>e.g., market players, competitive positions</td>
</tr>
<tr>
<td>Forecasts of tangible &amp; intangible impacts</td>
<td>e.g., reports of limiting conditions</td>
<td>e.g., test data &amp; usability studies</td>
<td>e.g., market size &amp; share, impacts of uncertainties</td>
</tr>
</tbody>
</table>
I&K Seeking & Use

- Value defined in terms of relevance (in time), reduction of uncertainty & usability of form
- Lack of perceptions of a large amount of untapped valuable information & knowledge
- Little time devoted to formal information & knowledge seeking & heavy reliance on other people
- Difficult translating information & knowledge across domains & across disciplines
- Poor followup in digesting information & knowledge accessed & using it to inform decisions
R&D Decision Making
Online Bibliographic Databases

- Users: Researchers
- Population: 60 engineering students and faculty members
- Methods: Five controlled experiments in three different online database environments and topical domains – agriculture, fiction & operations research
Summary of Results

- Nature of search questions and structure of knowledge (databases) strongly affect performance.
- Enhanced structural information improves performance if aiding in use of such information is also provided.
- User-tailored value functions can be useful to enhance performance, but users are not fully able to specify feature sets that define value.
- Poor follow-up of information & knowledge judged by users to be of high-value.
Design Decision Making
Design Information Systems

- Users: System designers
- Population: 240 people in seven aerospace companies as well as procuring agencies
- Methods: Direct observations, diaries, interviews, and questionnaires
Nature of Design Support

DESIGN SUPPORT SYSTEM

- MONITOR DESIGNER
- MONITOR INFORMATION
- PLAN SUPPORT
- SUPPORT GOALS
- EXECUTE PROCEDURES
- CONSTRUCT DISPLAYS
- DESIGN INFORMATION WORLD

DESIGNER

- REQUEST & ANSWER
- ACTIONS
- DESIGN GOALS
- PLAN
- INTERPRET

System Input
System Output
Designer Input
Designer Output
Summary of Results

- Environment of Design
- Design Challenges
- Design Methods & Tools
- Implications for Support
Environment of Design

- Pervasive and substantial impacts of market & business drivers on technology/design envelope
- Multi-attribute, multi-stakeholder, time-pressured, information & knowledge-rich problem solving and decision making
- Consequently, designers cannot systematically seek & use range of information & knowledge that might be expected from external perspectives
Design Challenges

- Understanding high-impact uncertainties in terms of distributions of impacts and criteria for decision making
- Difficulty of cross-disciplinary representation, manipulation, and (quasi) optimization of problems, requirements, and solutions
- Consequently, designers spend much more time communicating & negotiating than information & knowledge seeking
Importance of spiral discovery, prototyping, and evaluation processes vs. traditional waterfall approaches

Emphasis on targeted, specialized tools – rather than monolithic approaches – with, ideally, compatible representations and information flows

Consequently, designers do not pursue or expect global optimization of decisions; instead they try to reach satisfactory resolutions of tradeoffs
Implications for Support

- Cross-disciplinary – e.g., engineering, marketing & finance -- representation, computational experimentation, and (quasi) optimization of design solutions

- Compatible representation and manipulation of physical and preference “spaces” and determination of impacts of interactions and uncertainties

- Consequently, designers want “workshops” of compatible, targeted tools rather than an ultimate “shopsmith” that does everything
Management Decision Making
Strategic Management Tools

- Users: Executives & Senior Managers
- Population: Several thousand people in well over one hundred enterprises
  - 2/3 companies; 1/3 non-profits & government
  - 2/3 in the U.S.; 1/3 international
- Methods: Interviews, questionnaires, & notes from working sessions
## Summary of Initial Study

<table>
<thead>
<tr>
<th>Topic</th>
<th>No. of Sessions</th>
<th>Total Participants</th>
<th>Average Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Planning</td>
<td>43</td>
<td>905</td>
<td>21.0</td>
</tr>
<tr>
<td>Business Planning</td>
<td>52</td>
<td>1051</td>
<td>20.2</td>
</tr>
<tr>
<td>Consensus Building</td>
<td>5</td>
<td>82</td>
<td>16.4</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>2038</td>
<td>20.4</td>
</tr>
</tbody>
</table>
Example Planning Sessions

- **Product Planning**
  - Satellite communications networks
  - New lines of passenger vehicles
  - Next generation microprocessors

- **Business Planning**
  - Formation of a health information systems enterprise
  - Diversifying in markets for commercial aircraft systems
  - Orienting R&D toward internal markets

- **Consensus Building**
  - Abilities to convert from defense to commercial markets
  - Impact of impending environmental regulations
  - Success of ongoing total quality programs
What Teams Want from Tools

- Process
- Information
- Facilitation
- Surprises
Planning teams want a clear and straightforward process to guide their decisions and discussions, with a clear mandate to depart from this process whenever they choose.
Planning teams want capture of information compiled, decisions made, and linkages between these inputs and outputs so that they can communicate and justify their decisions, as well as reconstruct decision processes.
Planning teams want computer-aided facilitation of group processes via management of the nominal decision making process using computer-based tools and large screen displays.
Surprises

Planning teams want tools that digest the information that they input, see patterns or trends, and then provide advice or guidance that the group perceives they would not have thought of without the tools.
More Recent Experiences

- Training Only Viable in Context of Doing Real Work, Rather Than Just Learning
- Decisions Must Be Framed, Represented & Evaluated Within A Few Days
- Involvement of Key Stakeholders, in Real Time, Essential to Assuring Support
- Yet, Final Decisions to Commit to Plans Take Longer & Longer
Implications for Support

- Ease of Use and High Value Critical
- Value Cannot Depend on User Followup
- Easy-to-Learn Powerful Models Important
  - Knowledgeable Facilitation Essential
  - Domain Knowledge Helps Process
- Spreadsheet Invaluable for Staging Analyses
- Preparation of Top-Management Presentations
Online Management Services

- Online Article Service
  - Review of 30+ top journals
  - Tailored recommendations

- Online Management Journals
  - Multiple online journals
  - Reviews of 30+ journals
  - Reviews of websites
  - Book reviews, interviews, tools, etc.
Online Article Service

- Article recommendations from 30+ journals & magazines
- Targeted at issues at hand of 60 executives and senior managers, & tailored to these needs
- Almost 500 recommendations over 18 months
- Very positively received, but difficult to scale up – inexpensively -- for broader audience
Distribution of Recommendations

Article Recommendations

Recommendations Per Issue

Journal or Magazine

Harvard Business Review

Research Technology Management

California Management Review

Technology Review

Statin Management Review

Technology Review


Fortune

Invention & Technology

Forbes

Economist, The

Business Week

R&D - Research & Development

CFO

Competitive Intelligence Review

Strategy & Leadership

IEEE Spectrum
Online Management Journals

- Users: Executives & Senior Managers
- Population: 200+ subscribers
- Methods: Email and telephone interviews & questionnaires
Summary of Results

- Conversion Rate (Trial ➔ Paid) = 12%
- Reasons for Non-Conversion
  - The information provided did not match my immediate interests (33%)  
  - I already have too many information resources (25%)
  - I have no means to pay for this type of service (25%)
  - There are too many free information resources available to justify paying (17%)
Decision Support
Conclusions Across Domains

- Comparison of Domains
- Nature of Information & Knowledge Seeking
- Information & Knowledge Value Space
- Nature of Information & Knowledge Support
## Comparison of Domains

<table>
<thead>
<tr>
<th>Characteristics of Domains</th>
<th>Research</th>
<th>Design</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>New, fundamental knowledge must be created</td>
<td>Inherent</td>
<td>Occasional</td>
<td>Seldom</td>
</tr>
<tr>
<td>New knowledge must reference past knowledge</td>
<td>Inherent</td>
<td>Seldom</td>
<td>Seldom</td>
</tr>
<tr>
<td>New forms of representation must be formulated</td>
<td>Common</td>
<td>Occasional</td>
<td>Seldom</td>
</tr>
<tr>
<td>Existing forms of representation must be populated with information</td>
<td>Occasional</td>
<td>Common</td>
<td>Common</td>
</tr>
<tr>
<td>Formal sources of information must be considered</td>
<td>Common</td>
<td>Occasional</td>
<td>Seldom</td>
</tr>
<tr>
<td>Manipulation of representation constitutes the overall task</td>
<td>Inherent</td>
<td>Occasional</td>
<td>Seldom</td>
</tr>
<tr>
<td>Optimal answer is the overriding goal</td>
<td>Common</td>
<td>Common</td>
<td>Seldom</td>
</tr>
<tr>
<td>Satisfactory answer is the overriding goal</td>
<td>Occasional</td>
<td>Common</td>
<td>Common</td>
</tr>
<tr>
<td>Results of manipulation provide sufficient argument</td>
<td>Common</td>
<td>Occasional</td>
<td>Seldom</td>
</tr>
<tr>
<td>Results must be &quot;sold&quot; to a wide range of stakeholders</td>
<td>Seldom</td>
<td>Occasional</td>
<td>Common</td>
</tr>
<tr>
<td>Non-technical organizational considerations have a major impact</td>
<td>Seldom</td>
<td>Occasional</td>
<td>Common</td>
</tr>
<tr>
<td>Personal commitment to implications of results must be argued</td>
<td>Seldom</td>
<td>Occasional</td>
<td>Common</td>
</tr>
</tbody>
</table>
Nature of I&K Seeking

- Information & knowledge seeking affected by
  - Nature of questions & uncertainties
  - Extent & structure of information & knowledge
  - Usefulness, usability & urgency
  - External & internal drivers
  - Group-oriented processes

- Information & knowledge seeking made difficult by
  - Recognition vs. specification of I & K value
  - Incompatible representations across domains/disciplines
  - Lack of time & difficulty of convening groups
  - Primacy of immediate & mandatory requirements
I&K is valuable to the extent that it is USEFUL and USABLE and URGENT (ly needed)
Dimensions of Value

- **Usefulness** = Extent to which I&K helps users to pursue their intentions
- **Usability** = Extent to which I&K is easily accessed, digested, and applied
- **Urgency** = Extent to which I&K helps users to pursue near-term plans
Implications of Value Space

- Tailor choices among I&K sources provided to users’ intentions
- Tailor forms of I&K provided to users’ expertise and preferences
- Tailor choices among useful I&K sources to users’ plans
- Enable easy assessment of intentions, expertise, preferences, and plans
Nature of I&K Support

- Information & knowledge seeking enhanced by
  - Tailoring to intentions, expertise, preferences & plans
  - Aiding to exploit structure of information & knowledge
  - Aiding to generalize specific instances of value
  - Transformations across domains/disciplines

- Information & knowledge support should enhance
  - Decision making processes
  - Information tracking & capture
  - Facilitation of collaboration
  - Surprises gleaned from information

- All for near zero cost/benefit!
Summary

- Context of Decision Making
- Definitions of Information & Knowledge
- Information & Knowledge Requirements
- Types of Information & Knowledge
- Information & Knowledge Seeking & Use
- Three Domains of User & Four Solutions
  - Research ➔ Online bibliographic databases
  - Design ➔ Design information systems
  - Management ➔ Strategic management tools
  - Management ➔ Online management services
- Implications for Information & Knowledge Support