Earth Science Data Systems

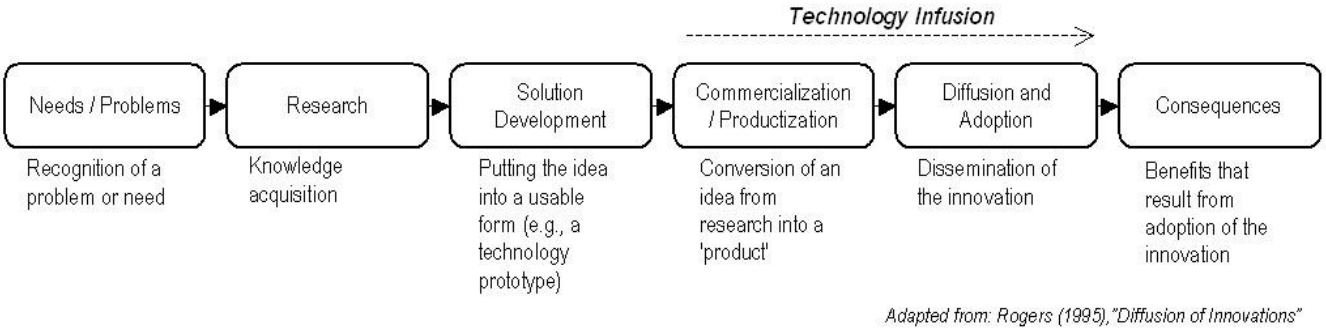
Technology Infusion Working Group

Technology Infusion Process Overview

Findings and recommendations of the 2005 Process & Strategies subgroup

The Innovation-Development Process

The innovation-development process[1] typically begins with the recognition of a problem or need. This may be an immediate problem/need requiring resolution or the anticipation of some future problem or need. We can think of the need both in terms of its proximity (how immediate is the problem/need and hence how soon do we need to act on it) and its criticality (how important is it and what are the consequences of not acting on it). This recognition of a problem/need leads to the initiation of research activities designed to establish a solution.



Phases in the Innovation-Development Process

In the Earth science data domain, the types of problem that we examine typically lead to research into technology-based solutions and to exploring how our data systems can be improved, extended, or refined. In the development phase, development activities involve the application of software engineering technologies and techniques to improve the usefulness, reliability, and accessibility of Earth science data.

Much of the research funded by NASA is directed at this type of problem solving and the development of technologies to a point of a demonstrable capability (equivalent to a TRL level of 4 to 6.) However, at this point in the innovation-development process, we have only demonstrated an ability to solve the problem in a limited environment. Further effort is required to make the technology robust enough for wide-scale implementation and to address the issues associated with the distribution and adoption of new technology by the wider community. And this is where we start to transition from what are usually regarded as research and development activities into what we can label as technology infusion – the dissemination and infusion of the new technology into routine usage within the wider Earth science community.

The productization phase involves the packaging of the innovation so that it is readily consumable by its target audience. In the case of software, this may mean more comprehensive testing and debugging in multiple technical environments, the development of installation and configuration scripts, and completing the documentation.

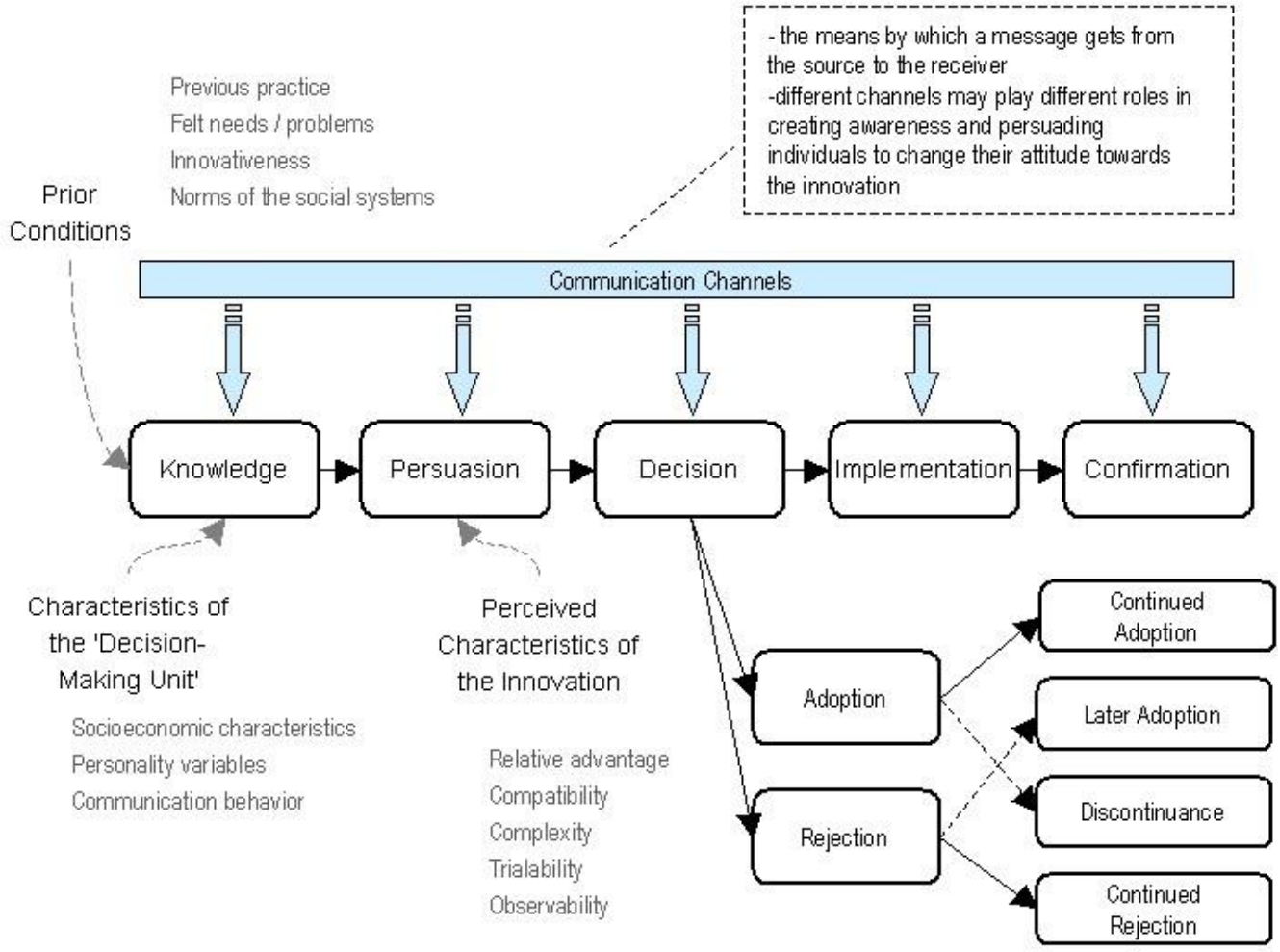
The dissemination and adoption phase is where the innovation is implemented in multiple sites. This is not merely a technical distribution issue. Persuading prospective users of the innovation to become adopters of the new technology can be a major task. We have to identify the prospective users,

[1] Everett M. Rogers, Diffusion of Innovations, 4th ed. (New York: The Free Press, 1995) pp132-154

communicate to them the benefits of adopting the innovation (often involving the replacement of some existing technology), and persuade them to make a decision to adopt the innovation. This can require a considerable marketing and communications effort.

The Innovation-Decision Process

The innovation-decision process[2] is the process by which the prospective user of the innovation forms the decision to adopt or reject the new technology. The Earth science community consists of diverse individuals, groups, and organizations, which often make independent assessments of the relative merits of new technologies and independent decisions on whether to adopt them. The model below describes some of the key steps and characteristics involved in the innovation-decision process. The success of a technology infusion effort depends upon persuading sufficient decision makers to adopt the technology being infused.



Adapted from: Rogers (1995),"Diffusion of Innovations"

[2] Everett M. Rogers, Diffusion of Innovations, 4th ed. (New York: The Free Press, 1995) pp163-203

The innovation-decision model describes the process by which the decision-maker transitions from first becoming aware of the innovation, through understanding the characteristics and benefits of the innovation, to making a decision on whether to adopt or reject. It also describes a subsequent implementation and confirmation phase during which the initial decision is revisited based upon the initial experiences of the innovation.

It is important to note the significance of the communication channels in the process – the means by which the decision maker first becomes aware of the new technology and then gathers sufficient information to make the adopt/reject decision. The means by which the decision maker acquires the relevant information, the quality of that information, and the reliability of the communication channels can be significant factors in the decision process.

The decision making process is not always based on perfect knowledge. The effectiveness of the communication channels will be affected by the extent to which the decision maker is proactive within the knowledge acquisition process. Few decision makers have the time or resources to dedicate to comprehensive knowledge acquisition for all of the possible technology options and therefore may be inclined to accept workable sub-optimal solutions rather than try to optimize every possible decision.

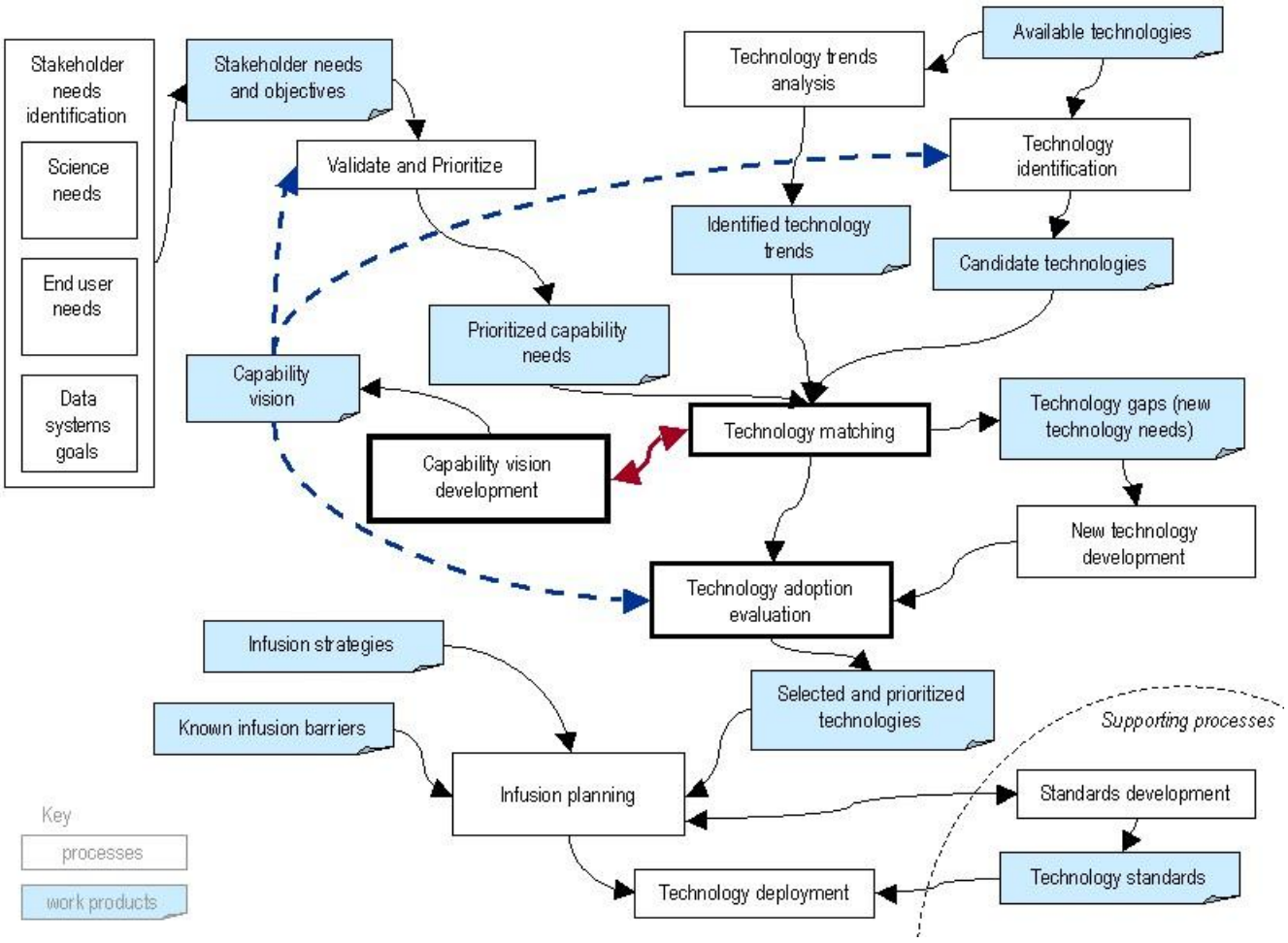
In the persuasion phase, we have particularly noticed the importance of the trialability and observability of new technology. New software technologies can be particularly complex and require a significant commitment of resources to successfully implement. The availability of software testbeds, for example, can be a useful way of demonstrating the effectiveness of new technology.

The TIWG Infusion Process

The TIWG Infusion Process diagram below takes a slightly wider perspective and examines some of the major activities and deliverables in the technology infusion process for Earth science. It also illustrates how the TIWG Capability Vision maps to the infusion process.

The diagram illustrates several aspects of the evolution from identification of needs to the widespread adoption of a new technology.

- *Needs identification* – the identification of technology needs and objectives to meet science goals.
- *Candidate technology identification* – the identification of new and emerging technologies from the Earth science and wider information systems communities that may be of value to Earth science data systems.
- *Technology matching* – the matching of new and emerging technologies to Earth science data systems needs and identification of technology gaps that may benefit from initiating new technology development.
- *Technology adoption evaluation and planning* – the selection of the appropriate technology or technologies for adoption and the determination of how the technology will be disseminated and infused. Some of the selected technologies may be submitted to the Standards Process to further support the maturation of those technologies.



Conclusion and Recommendations

We recognize that some of the activities in the process are more formalized and mature than others. For example, needs identification and prioritization seems to be reasonably well covered, whereas others are less formalized (e.g. technology adoption evaluation) or very informal or ad-hoc (e.g. technology trends analysis). The following possible future TIWG activities may help improve some of the weaker aspects of the process:

- *Infusion Education*

  Some technology infusion barriers result from insufficient awareness of how technology infusion works at both the NASA management and the project level. We observe that infusion is 40% a technology issue and 60% a marketing, brand awareness, and communication issue. As engineers and scientists, we may be great at solving the technical issues, but are not necessarily experts in the product marketing needed to promote a new technology. The TIWG should consider producing guidelines (e.g. template technology infusion plan), white papers, and presentation materials to help communicate some of the principles of technology infusion. We should present these 'principles of technology infusion' at community related events (e.g.,

Federation meetings). We should also collaborate with the Office of Technology Transfer, to leverage their expertise and resources.

- *New Technology Awareness*

  Another infusion issue relates to how a prospective user becomes aware of a new technology and gathers sufficient information to make an adoption decision. To address this issue, the TIWG could establish a web site / wiki, or work with existing publications and/or events to provide more opportunities to promote and discuss new technologies.

- *Technical Support*

  The cost / complexity of providing product support has been mentioned several times as a potential barrier to infusion. Increasing funding levels for technical support may be difficult to achieve within current budget constraints. Alternatively, the working group could develop a web-based technical support tool (there are open source products that could be used as a starting point) that could be easily deployed by projects to automate support tasks (bug reporting, release notifications, patch downloads, user discussion forms etc.). We could also consider hosting such a system ourselves so that a new project would just have to be configured as a user and then have access to all of the facilities. This would help to reduce the burden of technical support for the provider.

- *Funding for Infusion*

  The TIWG does not have direct access to funds to allocate to technology infusion project, but we could consider assessing the real costs associated with technology infusion. We suspect that everyone is currently underestimating what is involved.

- *Technology Assessment Process*

  We should not assume that all new technology needs to be infused, but which ones should? We should consider the development of (and implications of) an assessment process that would evaluate new technologies and assign them an infusion priority level ranging from 'mandate' (you must use this), through 'endorse' (we like this and encourage you to use it), 'permit' (you can use this if you like), and 'terminate' (no further use for this).