

FINAL REPORT ON PUBLIC ACCEPTANCE AND RECOMMENDATION OF PUBLIC DISSEMINATION

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ABSTRACT The present document constitutes the deliverable D33.2 of DiPoP WP 33. It contains the final recommendations on public acceptance for DiPoP which have been derived from a reflection based on a literature research and a case study. It was found that public acceptance is prerequisite to the full success of any project and can be achieved through a rational/emotional balance. For this, a multidisciplinary work is necessary, entailing theories such as the Social Implementation of Technology and the Public Understanding of Science. Other important aspects are the roles of responsibility in the technical and the liability in the economical set. Departing from general recommendations, a public dissemination plan for DiPoP was drafted. While the scientific public dissemination appears as a regular activity, the dissemination to the general public also demands social activities and commitment.					
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2. Introduction

In any society, the realization of major projects of general interest, i.e. a project making sense and responding the society's needs and problems, depends on the project's integration within the society and the solidarity the project's responsible receive [R 4]. In the past, the positive emergence of this social fact was coined "*public acceptance*" – a term which is maintained throughout this document for historic continuity and despite being flawed as it insinuates that it concerned affairs of a bad state while the actual emergence does not necessarily. Examples in the past showed that independently of the value of the project, poor solidarity risked its failure which was typically seen as a result of poor public acceptance or poor public understanding [R 5]. This is in particular true for technological and scientific projects. One technological example is the abandonment of the terrestrial nuclear power provision in European countries such as Germany, Switzerland, Spain and Belgium due to the general public withdrawing its support following the disasters of Chernobyl and Fukushima.

The case of the Stop-Cassini movement points out that this debate is also relevant for space flight missions to destinations outside of the reach of sustainable solar power provision and therefore depending substantially on nuclear technology. However, older surveys reveal that there are sections of the public who are critical about space flight even beyond nuclear safety and environment concerns [R 5]. A distinction appears here between the *means* on one side and the *purpose* on the other side making a twofold case for a reflection of the social aspects of technological implementation in the frame of the project on ***Disruptive Technologies for Space Power and Propulsion*** (DiPoP) aiming at the enhancement of Europe's space flight capability which also encompass nuclear concepts. The present report outlines this reflection and summarises its results wording primordial recommendations and drafting a dissemination plan.

To date, this reflection is of a rather abstract nature relying mostly on literature study. Two main approaches were identified in the literature: The concept of *Social Implementation* [R 4], focussing on the role of project responsible among a society and the *deficit model* underlying the *Public Understanding (of Science)* [R 5] concerning dissemination activities. The reading was verified considering the example of the social implementation process of the infrastructural venture of Stuttgart 21 which was chosen because of its geographically, temporally and thematically concise nature. Another fact which made its consideration favourable consists in it being witnessed by some of the present document's authors.

In the course of this process, it has been understood that public acceptance consists in an equilibrated emotional/rational balance demanding an interdisciplinary calling for expertise from natural and social sciences. From the reflection of the findings through this approach, directives for the experts in general are combined into recommendations for public acceptance of the DiPoP project and a respective dissemination plan. While the dissemination to the scientific public appears to be sufficiently covered by regular scientific publication activities, the dissemination to the general public demands social activities and commitment. It aims at both educating the public on the technologies and at enhancing the social implementation.

In the next section the setup of the model and the terminology is introduced (2.2), then the public acceptance process of Stuttgart 21 is described (2.3). In chapter 3, findings from social sciences, most notably the social implementation concept and communication are discussed. Chapter 4 contains technical considerations and a generic safety approach while chapter 5 introduces to the involved economic aspects. The dissemination plan is developed in chapter 6 before concluding.

2.1. Public acceptance as a prerequisite to the realization of major projects

The *Public* is the sum of various groups of individuals observing the project from the outside or being exposed to the projects effects. The responsible for a project are called according to reference [R 4] *experts* or *technical elite*. There are various kinds of *public* not distinguished within this reference. They need to be interacted with in an appropriated manner. There is a *scientific public*, a *media or journalistic public*, a *public of stakeholders and politicians*, and the so called *general public* which is the actual sovereign body of the society and on which this document is focussed for the sake of simplicity. The other types of public should rather be considered as intermediary acting groups outside project proponents and opponents.

Also the way these groups interact will be different and in the following, a set of the most important interactions is introduced and shown in Figure 1. The experts will affect the general public through their project and the general public will *adopt* the project or *elide* it – the process of which is the subject of the present document. The politic public either funds or controls the project by mandate of the general public in its role as the sovereign. The scientific public also controls the project but there is also competition with the experts. The media produce journalistic coverage of the project in order to inform the public.

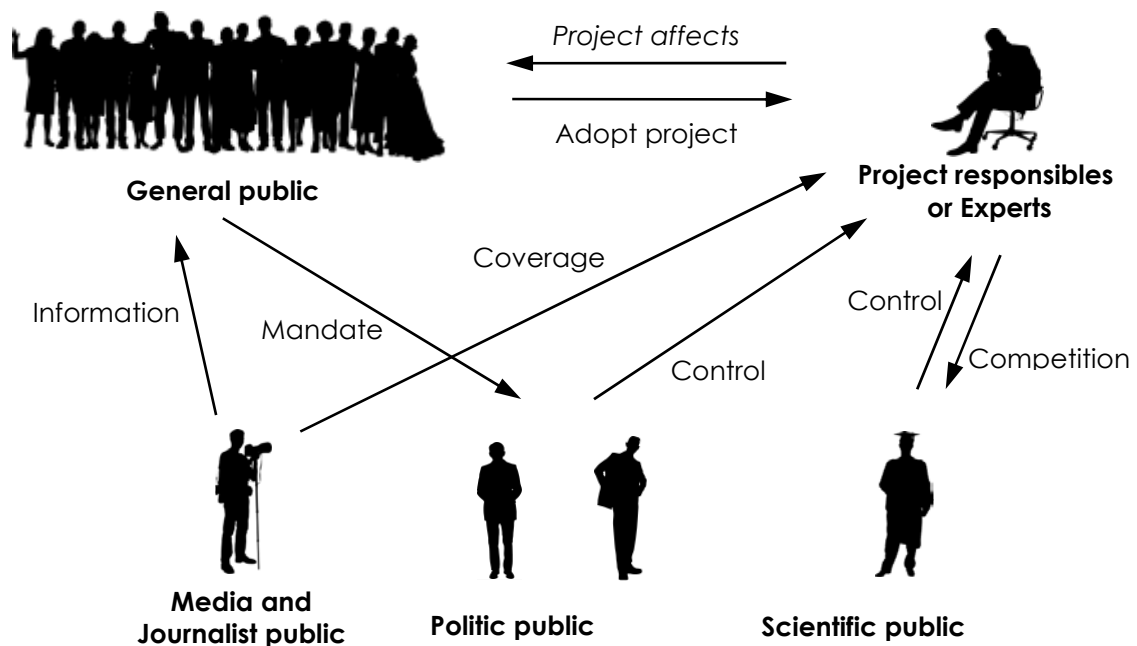


Figure 1 – The public and the project responsables.

Public acceptance is the state in which a significant part of a society has a positive or at least neutral stance towards a given project which may be of a social (e.g. demographic policies such as the one-child-policy) or a technical (e.g. nuclear power) nature. The terminology “*acceptance*” is however flawed, as it does not correctly describe the emergence which is consisting in the solidarity the experts receive and thus the actual *adoption* of the project by the public and as it further suggests that the project was either ethically dubious or generally in a bad state. It is however a necessary premise for the reflection in this document that the project is in a good state and ethically sustainable.

Public refusal or elision is the opposite of public acceptance. It consists in a majority opposing a project and obstructing if not even preventing its ultimate realization. This may consist in protest like strikes or rallies in the street, political action manifested in elections or referenda or – in the worst case – open riot, revolt and attempts of overthrow. However, there is also the obstructing effect of the non-accepting public simply ignoring or neglecting to implement the project's means. This also includes the so called civil disobedience. While most of these emergencies appear in general in the case of large scale projects, those applicable on individual scale can also encounter a simple avoidance or boycott of a product.

Dynamic of public acceptance: Public acceptance can also vary throughout time. An initial public refusal may grow into public acceptance and vice-versa or even return to the initial state depending on the public's changing perception of a project, the problem it seeks to resolve or its *purpose* and its *means*. The acceptance evolves due to both a dialectic and an emotional conflict observed by the public and its stately instruments among two acting groups, the proponents and opponents of a project.

Examples: The effects of having or gaining, not having or losing public acceptance can be observed in many cases having occurred in the recent past, the so called post-war era. Two of them are briefly presented:

- For one, there is the example of nuclear power in Europe, where various different stances exist. In Britain [R 6], nuclear power was accepted and faced a relatively minor refusal. This refusal is even declining in view of climate change. Nuclear power is in large extent accepted in France, Sweden and Finland, where even an ultimate disposal facility comes into existence. This is different to Germany [R 7]. The difference between public acceptance of nuclear power in e.g. Finland and Germany is captured in Figure 2 at the bottom of this page. In Germany, accidents affected the general public in a way which forced the politic public to legislate the abandonment of the technology. While having a general approval of the general public during the 1950s and 1960s, the 1970s marked the beginning of a shift towards a wide spread disapproval. In the beginning, the disapproval founded on the worries that coolant clouds might obscure the sun and therefore reduce the crop output of vineyards nearby. Later, especially after the Three Mile Island incident and Chernobyl, it founded on the fear of physical harm due exposition to radiation and fall-out and on the perceived doom of ultimate disposal. The Fukushima Daiichi average rekindled the anti-nuclear movement.
- On the other hand, there is the example of the Internet as a formerly highly advanced communications concept having achieved high public acceptance and being widely

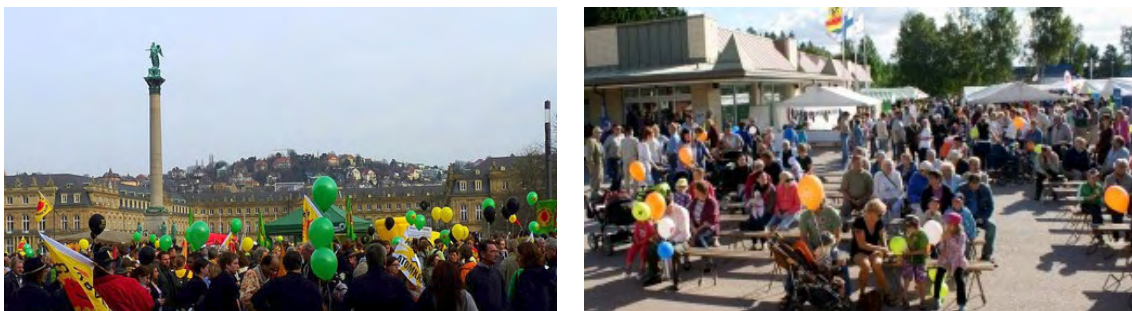


Figure 2 – Anti nuclear protests in Stuttgart, Germany (© Stuttgarter Zeitung) and the Finish town Eurajoki welcoming the ultimate disposal (© finland.fi). Same technology – different acceptance.

adopted. By the time it was developed in the 1960s, it was a military project called “Arpanet”. It was limited to a small group of militaries and scientist. While it was still argued in the 1980s [R 4], that the internet (and with it PCs) will never reach large portions of the population due to the high aptness threshold in using computers, the 1990s saw a first significant increase in number of users. The availability of new browsers and communication purposes made the technology attractive for civil users, i.e. the general public. PCs became cheaper and the new computer operation systems offered by Apple and Microsoft contributed to this because they made the computer being easy and user friendly even for people lacking special training. It can also be argued that Apple’s approach to progressively give up the command line approach in favour of the graphic user interface was decisive since it offered something pretty and visual more welcome to the human nature than an abstract line of symbols considered being “cold” by many. The current wave of social web applications is both a proof for the adoption of the technology and an example for a new communication purpose.

2.2. Interdisciplinary approach to public acceptance

These examples allow concluding that achieving public acceptance for realizing and using disruptive technologies is an interdisciplinary project demanding long term effort prone to unexpected shifts of opinion and social dynamics outside of the project’s technical scope.

This is because, for a single individual, adopting a project is based on a *Rational / Emotional Balance*, see also Figure 3 on the next page. While there may be many good rational arguments to opt in favour of or against a project, there may also be emotional reasons to do the respective. It can actually be observed that in many cases in which the public does not adopt a project of disruptive technology, it is not out of rational weighting, but out of emotions founding on an abstract fear or because of the subjective impression of not being addressed by both the technical elite and the government believed to be the nominal decision maker. The actual decision maker, however, is the general public, composed of individuals deciding according to the rational / emotional balance.

On the rational side, an individual needs the support of intelligible data and knowledge bases informing him on a project’s facts with respect to its purpose and its means so he can form a qualified opinion. These facts need to be made up of a transparent technical description, a design justification addressing both drawbacks both advantages and pointing out possible alternatives and most especially an explanation why the alternatives are conceived to be inapt by the responsible. The facts also need to address economic costs and gain in a very transparent manner. These requirements are calling for approaches from not only engineering and natural sciences, i.e. from the technical faculties, but also from economics. Since both technical and economic aspects of the rational side are reposing on seizable data, one can qualify political approaches to support this part of individual decision making as being straightforward. Typical questions characterising this may be: “*What do we know? Does it pay? How severe are the risks? What can they prove?*”

The emotional part of it is less straightforward. Emotions do not follow facts but rather psychological stimuli, cultural values, social integration, communication and even aesthetic considerations. An individual’s emotional perception of a project may differ in large extent from his rational evaluation and even outweigh the latter if it came to choose. For example, psychological archetypes may incite an abstract fear related to the means surmounting the

objective assessment of harmlessness; the perceived isolation and apparent secrecy of the executing elite may cause the impression of being delivered to a “conspiracy”. Also the purpose may appear as relatively uninteresting or unworthy to the general public. Accordingly, any policy aiming at raising the public acceptance needs to consider psychological, sociological, communicational and anthropological facets of the project and its processes. These facets form the anthropological aspect of public acceptance for the project. Typical questions may be: “*How do we feel? Is it worth it? Is it dangerous? Can we trust the experts?*”

These typical questions are summarised in Figure 3, alongside with the rational ones. Figure 4 on the next page shows an overview of the various aspects in achieving public acceptance. The rational aspects can be split into *economic* and *technological sets*. The emotional aspects are purely human and mirror in the *anthropologic set*. Respective issues and means to respond are included in the sets. Respective disciplines are noted outside the sets. For example, there are physical risks intrinsic to the technology – accidents and pollution come to mind – that can be responded by risk assessment and application of ecological standards. This work is mostly calling knowledge about physics and competences in engineering. Also, there are intersections:

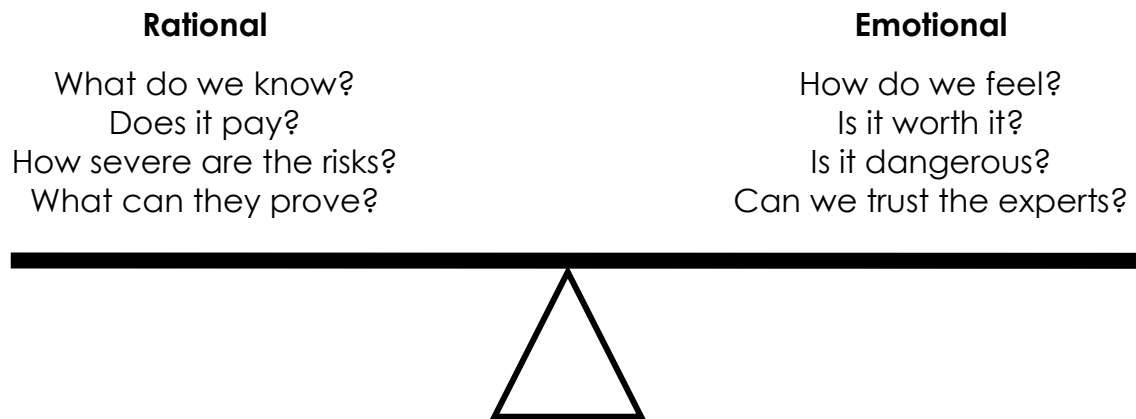


Figure 3 – Rational / Emotional Balance

The intersection of the technical and economical aspects sums up in the economic sustainability of the technology: The cost of the technologies involved, the cost of the risks and their mitigation, the direct returns of investment or the indirect added value chain induced by the technology and the potential long term spin-off benefit (including a weighting) have to be thoroughly estimated in order to predict the sustainability. Yet, the most important aspect here is the question of liability in case of incidents or pollution: In the example of nuclear power supply it is often reproached that the technology’s benefit relies to a large extent on the externalisation of the costs related to risks and detriments which are incurred by the general public in its role as a tax payer.

This aspect has a direct counterpart in the *intersection of technical and anthropological aspects* which can be called “*responsibility*” and is about the roles and instruments in mitigation scenarios. Many of the emotional responses and social reactions impeding technological projects ranging from aviation to particle colliders are related to the perceived physical risks and a feeling of being helplessly delivered to those emanating from an absence of trustworthy instruments and staff to mitigate the risked detriment. For example the general public is more likely to implement flammable technologies such as gas or oil pipelines rather than nuclear power plants. This is because it estimates that the specially trained fire brigade can control the risk from fire while it

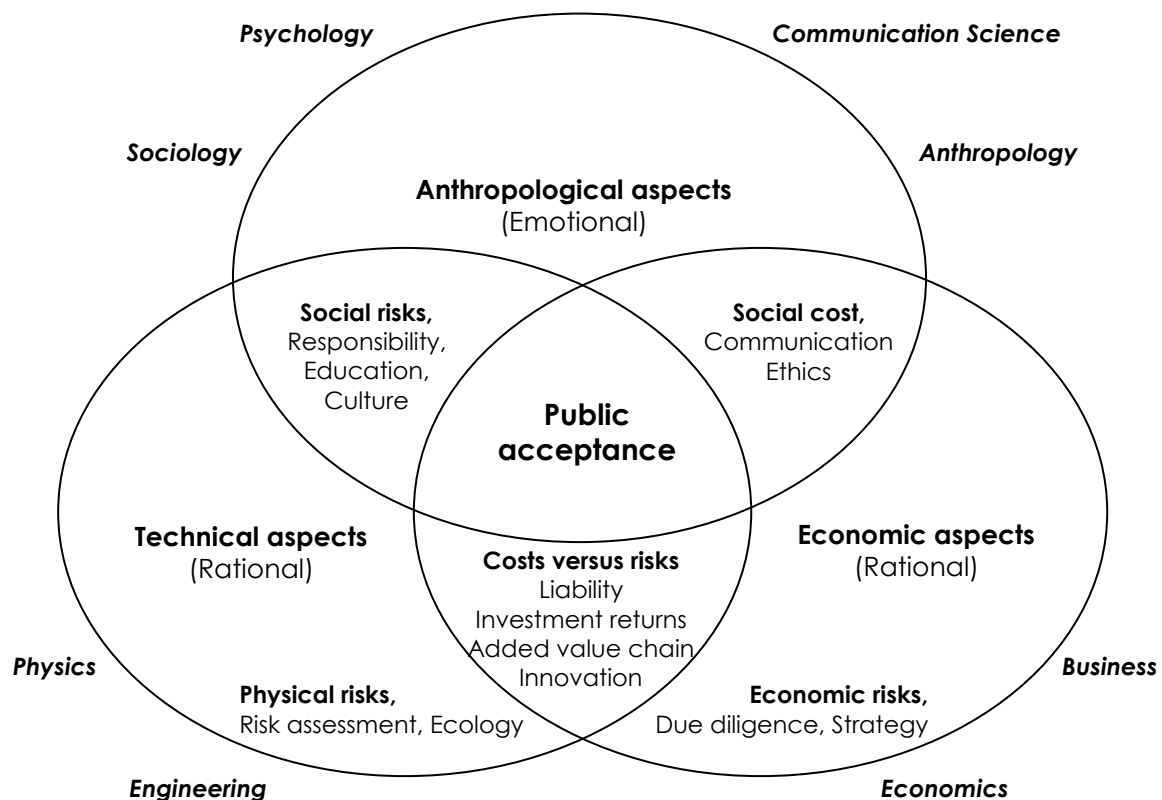


Figure 4 – Venn diagram of the aspects to be addressed in order to achieve public acceptance.

does not perceive the fire brigades means suitable to meet with a nuclear average, especially facing the media coverage on the incidents in Chernobyl where they had drafted liquidators without special training and in Fukushima Daiichi where the fire brigades' means appeared to be puny facing the mighty power of the reactor blocks. But the fear of being delivered is only one element among many others in which technical knowledge has to meet psychological and sociological realities. For example, there are cultural realities that need attentive study, like the values people cherish in their lives and that may be infringed by applying a given technology. Obviously – and especially in the case of projects in the exploratory space flight domain – there are strong positive elements, like innovation (which is despite a general trend to refusal of particular projects publically considered to be good), adventure and cultural progress that can incite strong project enabling sentiments, as witnessed e.g. with the American Apollo programme.

Finally there is *an intersection of economic and anthropological aspects*. In general, one finds two main topics needing discussion in this field. The first is the economic exchange between the society and the project also encompassing individual wealth. Many advanced projects are public funded and compete therefore with other items in the public budget, like for example pensions, public health, refunding of prior debts, development aid and others. In this, there is a need to justify the expenses for a project of advanced technologies. The second is the economic transparency calling economics and communications. A commonly observed response to an opaque funding is to suspect the participants of fraud or corruption. Taken a general tendency in modern western society that if one has nothing to hide everything can be disclosed, this is rather understandable. The question is: "Why do you hide?" Under these conditions, independently of what the opponents claim, they may actually rather be against bad business practice than against the technology. Meeting the public with transparency can avoid this mode of refusal.

2.3. Case example: Public acceptance of Stuttgart-21

The infrastructural project *Stuttgart-21* which aims at an augmentation of the railway capacity of the region of Stuttgart, Germany, through advanced concepts and disruptive approaches can be perceived as an ideal showcase of public acceptance. It is concise in both geographical and thematic nature. In this section, the project and its history are briefly introduced before describing the shifts in its public acceptance and offering an interpretation in view of its implementation.

Stuttgart-21 is part of a series of railway station projects called “*Bahnhof-21*” in the framework of the *Netz-21* strategy of the *Deutsche Bahn*. The strategy dating from 1995 aims at an enhancement of the performance of the German railway net through separation of faster and slower traffic. It also provides parts of the *Magistrale for Europe* which aims at establishing a high-speed railway network connecting Paris and Budapest. This is the *Trans-European Networks* Project 17 also dating from 1995. For the Stuttgart-Region this stipulates a cut of the travel duration between Stuttgart and the town of Ulm, another mark on the envisioned *magistrale*. For this aim, the reconstruction of the railroads connecting both towns was thought over. It was decided to improve the current relatively steep climb instead of shifting to a softer slope. A restructuring of the Stuttgart main station dating back to the 1980s was decided. This is shown in Figure 5 below.

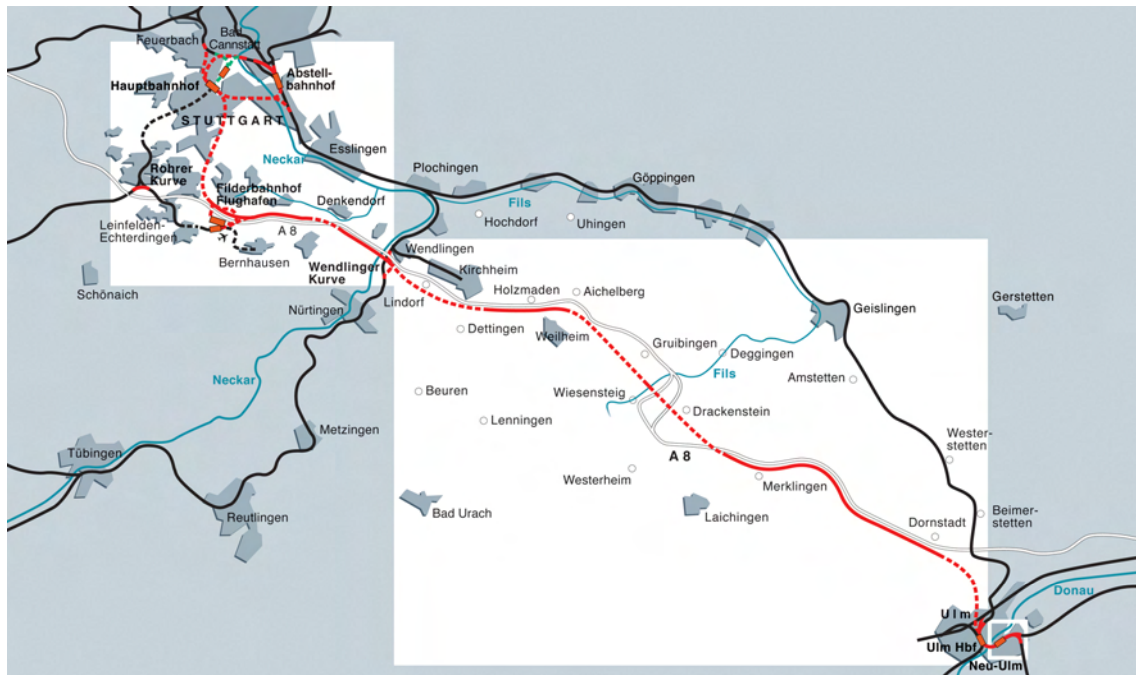


Figure 5 – An overview of the Project Stuttgart 21 (© Deutsche Bahn).

The new main station concept designs a ninety degrees turn of the railroad in the station in order to make the route parallel to the *magistrale* instead of having a perpendicular terminus station. This can also allow for a reduced number of tracks compared to the current situation and hence a better logistic. To enable this approach, it is also planned to create subterranean departure platforms and connect the station via two tunnels, one heading to Feuerbach in the West of Stuttgart the other heading to the Airport in the South-East. This would also release a considerable area for urban renewal of the City of Stuttgart. The decision to do so was already

made in 1994 after evaluating various development plans and variants. The construction was started in 2010 and is supposed to come to an end in 2019.

In the second half of 1990s, the Stuttgart-21 project earned general public acceptance. A 1995 poll conducted by the administration of Stuttgart showed that about 51% of the interviewees were positive to the project and only 38% negative [R 8]. In late 2008 however, it was reported that about 68% of the interviewed persons were against the project [R 8]. More and more protests and rallies in the street ensued. Finally, in September 2010, a growing momentum of the protestation and a misguided approach on mitigating actions led to an outbreak of violence most uncharacteristic for Stuttgart [R 9]. In the wake of this outrage, a broadcast mediation was undertaken, the party ruling in Baden-Württemberg for over half a century lost considerably in the following election [R 10] and a referendum was held yielding that 58% of the participating electorate was in favour of the project's continuation [R 10]. These records reveal how strongly the public acceptance of the Stuttgart-21 project varied in the past.

Investigating these dynamics is interesting for the understanding of the processes and mechanisms of public acceptance. It may be assumed that the general public was initially in favour of the project due to optimistic assumptions and promises concerning the public transportation and due to the positive outlook of urban renewal in an area of the city which is loathed for the ugliness of vast railway installations. These positive aspects seemed somewhat natural and the public attention to the project diminished. However, in the later phase of the planning, the public regained interest in the project. With increasing precision in the planning delays and an increase in cost appeared as it was expectable. Due to a lack in transparency this information grew into exaggerating rumours inciting negative feelings and mistrust against the project actors. Groups in opposition subsequently established three main points of critique:

- *Excess in cost,*
- *Lack in consumer friendliness and bad economy, and*
- *Environmental damage.*

A considerable effort was undertaken to flesh the threats out, often in neglect of well founded contradiction from proponents. For the sake of proving the diminished user friendliness, it was argued that the reduction in platforms would make the new station prone to delays leading to a complete collapse of railway traffic in the region. This supposition was proven wrong in a simulation performed by independent Swiss experts [R 12]. It was also said that the option of a through station endangered the train accessibility by physical impaired persons. This did not take in account the use of elevators. Also safety aspects were brought up like the slope of the platform. However, a steeper slope can be found in some of Stuttgart's metro stations, which are not debated. Another safety issue seen by the opponents was the fire protection within the tunnels calling for a redefinition of the responsibility means.

The project was qualified to threaten the environment because the tunnel construction might interact with the ground water resources of the city in ways that might have appeared in prior constructions sites nearby, e.g. the subways [R 13] which reveals that there is a lack of understanding of the enacted technologies making a case for enhanced dissemination strategies. Further, the opponents feared the tunnel digging could trigger a geologic catastrophe which would eventually make Stuttgart's buildings crumble. The felling of trees near the construction site was judged to be problematic for the ecosystem of the city [R 14]. These reproaches also encompassed questions of liability as to who was going to compensate eventual damages.

The excess in cost hinting already in the mid 2000s was interpreted as a waste of public funding that might otherwise be used for other projects like schools or healthcare systems in the worst case and a considerable increase in tax payers' duty in the best case. A third case often outlined by opponents was the so called "*Multi Billion Euro Hole*", a scenario in which the funds would run out before the completion of the project leaving Stuttgart with an unfinished main station only partially operative. This argumentation ignored that the allocated funding was dedicated to the enhancement of infrastructural means. There was also a fear of corruption and it was claimed that an isolated group of interests pushed the project beneficial to them forward, conspiring ruthlessly against the good of the majority of citizens.

While the first two types of argumentation can in general be refuted by technically educated or understanding persons and in the worst exception met with technical countermeasures, and while the fact based economic considerations can be treated in a similar way, the emotional background of the opposition clearly shows in the claims of conspiracy hinting at a faulty social implementation of the project with the responsible being remote from the population or *alien*.

The lack in transparency even despite project delays and cost increase and the maintenance of opacity even despite more delays and more cost increase has tipped the rational/emotional balance at one point to the side of negative emotions like mistrust and alienation despite rational debate being available. Even more, the dialectic of the rational debate froze because the highly emotionalised public always put further effort in rationalising negative emotions through elaborating new rational explanations in what way the project was "evil" to the majority of the population. Risks were overstated. Benefits were understated. Contradiction coming from proponents was turned down immediately out of mistrust.



Figure 6 – An Anti Stuttgart 21 badge, resembling German out of town road signs to communicate the intent to abandon the project. Symbol of the opponents' media dominance.

The impact of this attitude was strengthened through means of communication and marketing. Opponents used low cost and easy access means of distribution very early and steadily enhanced it. From the beginning they used flyers and especially badges (see e.g. Figure 6) to promote the attitude of opposition. Seeing anti project badges nearly everywhere in town had a certain psychological effect on the population. Gathering frequently for speeches excluding external experts favouring the project and project proponents strengthened the isolation of the latter on one side. On the other side, it enhanced the identification of large parts of the public. Information was distributed through several web sites. Local celebrity was won for the opposition and encouraged to participate in the communication. Also deviant external experts – note the problem of also achieving and maintaining solidarity among the scientific community – were called to support the rationalised part of the opposition's argumentation. The campaign spread the opposition's attitude from the political margin across the whole of the society encompassing every class. Unemployed youngsters and blue and white collar workers were opposing as well as the higher bourgeoisie.

The success of this media campaigning is neither to be found in the campaign itself nor in its efforts and output, but mostly in the neglect of a correspondent campaign in favour of Stuttgart 21. It was not until 2010 when comparable measures were started. Also, once started, the means made a rather artificial impression because they consisted in simply mirroring the opponents' campaign and because it was strongly funded through stakeholders who mistrusted the opponents in their turn. Also one has to note that the moment to admit participation and therefore enable an open debate was missed around 2005 when problems with the project funding and ecologic arguments against the project came to the public's awareness and started to grow into the opposition movement. Building up a counter campaign around 2005 might have avoided the tightening of both groups that lead to tensions formerly unknown among the population of Stuttgart and in the end to the outrage of September 30, 2010, nowadays called "*Black Thursday*", in which police and opponents had a for Stuttgart uncommonly fierce battle causing several injured participants (Figure 7) [R 9] and entailing some political turmoil [R 10].



Figure 7 – Stuttgart ,September 30, 2010. Public refusal leading to physical violence. (© Der Freitag)

It was only this event that led to direct action to bridge the gap between opponents and proponents. Making the project more transparent and opening it for participation was undertaken. A mediation process (see Figure 8 on the next page and [R 15]) was organised and Heiner Geißler, an experienced political veteran respected by both lairs, found to moderate the discussion which took place in eight sessions distributed over about six weeks. The public discussion was broadcast on German publicly funded documentary and parliamentary TV station Phoenix. Many aspects were discussed and problems identified, solutions demanded. Following Geißler's arbitration the conflict deescalated to a large extent.

Another interesting consequence partly owing to the Stuttgart21 question – but more likely related to the Fukushima incident – was the change of regional administration in March 2011. After almost 60 years in power, the conservative party was displaced by the ecologist party. The latter enabled a referendum on the question whether the state of Baden-Württemberg should or should not retract from the funding of Stuttgart21 and hence make it impossible. This referendum was won by the proponents on November 27, 2011 with a majority of 58% of the participating electorate [R 11]. This led to the opposition movement losing a significant part of their support. However, the few remaining opponents continue to protest against the project and



Figure 8 – Mediation among opponents and proponents of Stuttgart 21 conducted by Heiner Geißler. (© Tagesspiegel)

set strategies into work aiming at obstructing the completion of the project, e.g. through filing legal cases, preliminary injunctions and preventing execution through gatherings on the site.

An analysis of the example of Stuttgart 21 supports the conception that an interdisciplinary approach is necessary to achieve and maintain public acceptance. From the reaction of the opposition movement it can be directly seen that a fact based rational discussion is not sufficient and will not be accepted once negative feelings have built up culminating in isolation and mistrust. It can be traced that mistrust in the case of Stuttgart 21 was mainly caused due to a lack of transparency concerning funding. The negative emotions were equipped with rational counter-arguments but remained fundamentally subjective. It can also be argued that the disparate use of communication augmented attitudes. The initial reluctance to communicate on the proponent side may have been caused due to the want of commodity in seclusion from critique. However, this increased the difficulty rather than solving the problem since the opposition's momentum built up accordingly to the time passed without any open debate. Proponents hence have to be blamed for withdrawing and ceding the discussion to the opponents. This is the main reason why opposition persists even despite the project favouring result of a democratic referendum.

From the example of Stuttgart 21, it can be seen that

- achieving public acceptance demands both rational and emotional considerations;
- it is not only necessary to have a rational argumentation but to communicate it in time;
- it is important to timely respond to emotions and public concerns;
- it is necessary to spread information, maintain transparency and allow for participation;
- roles of responsibility and liability need to be accessible to the general public.

Also, it can be found that omissions in public acceptance considerations can easily incite negative emotions rationalising into an argumentation carried by opponents among the public. Once they gained momentum, it can be very difficult to bring this momentum to a stop. This is underlining the need of a thorough reflection of public acceptance and diligence to maintain.

3. Anthropological aspects of public acceptance

From what was depicted above one can conclude that if a technological project is well prepared in a technological and economic manner – which is the general case – and in impeccable ethic state – which is the fundamental premise of the present consideration – its realisation depends on its social implementation and the public. From this point of view, having or not-having public acceptance is a question of social support of the project and the solidarity its responsible receive. The latter is a question of the responsible's ability to both prepare for and respond to the general public's emotional objections. Emotional objections will not likely show up directly but rather manifest in a rationalised way using a pretext physical reasoning.

The type of emotions addressed in this document is of both an anthropological and a social nature. It can be righteously assumed that these emotions found on larger psychological processes of the individual and on his culture. On the other hand, the individual human is intrinsically part of a society and therefore involved in social processes. Therefore, educated interpretations from social sciences, communication sciences, psychology and general anthropology are needed to aptly respond to a given public's attitude towards a project.

In this chapter, the social aspects of public acceptance will be briefly discussed. Identifying public acceptance processes as social processes, the focus is set on social disciplines as according to Durkheim's positivist methodology only social causes can explain these [R 16]. First, the necessary social setup for a project is discussed, then the consequences for a projects communication will be developed, and finally an anthropologic and cultural directive is presented before concluding in a draft for a framework.

3.1. Social Implementation Of Technology

The common conception of realising a project leading to the "implementation" of a disruptive technology tends to be driven by the "implementation" term in engineering sciences. There, it specifies the deed of creating a tool like a code or a measurement instrument one has decided to create in order to answer a given question [R 4]. The respective process is drafted in Figure 9.

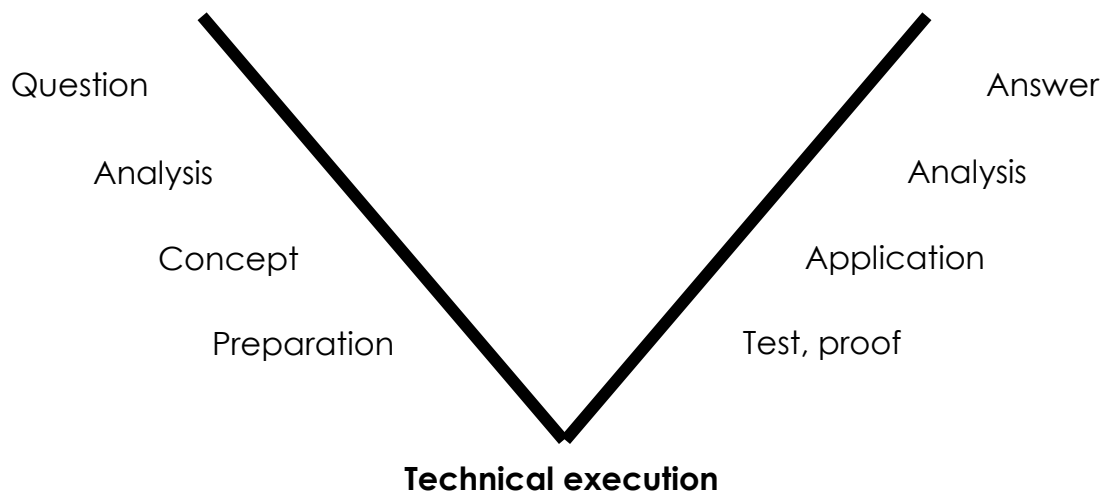


Figure 9 – Technical implementation as a process

On a social scale, however, the implementation term also covers the political decision process, the underlying development of both social relations and commitment, and the public's life with the technology. This is the Social Implementation of Technology (SIOT). According to [R 4], the quality of the social relations governs rationally the public acceptance and can affect the decision process. These relations have to take place between the public and the project's responsible, henceforth called *experts* in this document. In [R 4] this group is termed "technical elite" and thought to be composed of scientists, engineers, administrators etc. The relations are good if the public is able to identify its beliefs, intentions and desires with those of the experts: Sharing interests and culture creates sympathy and solidarity easing according political enactment. The design of the technologies applications needs to be according to these relations in order to maintain a daily life acceptance, use and support of the technology.

The opposite would consist in bad relations, i.e. if the public perceived the experts as social risks. Social risks consist in "alien" opaque groups that might impose unwanted accomplished facts to the own group or involuntarily change or even dissolve it and hence endanger every individual within. Perceiving a social risk is equivalent to mistrusting the group made out to be one. In practice, any kind of "anti" attitude is a reaction to such a perception, founded or not.

In the case of technological projects, the experts executing the project may be perceived as an "alien" opaque group by the public, which is composed of mostly non-experts. This perception can also be self delusional since it may also fund on stereotypes and uncontested preconception. The experts are "alien" because the public does not necessarily share the work, life, education, terminology and believes of the experts, which is visualised in Figure 10. And, if the communication between both groups is not sufficient to allow for transparency and trust, it can be opaque to the public. Then, if there is the slightest ground for suspicion the public will rally open opposition against the project, yet aiming the experts.

Following [R 4], there is an unconscious trend to communicate insufficiently with the public. There are three main drivers for this. First, there may be lengthy discussions in which a lot of the expertise proper to the experts needs to be explained at a very basic level and in a language very

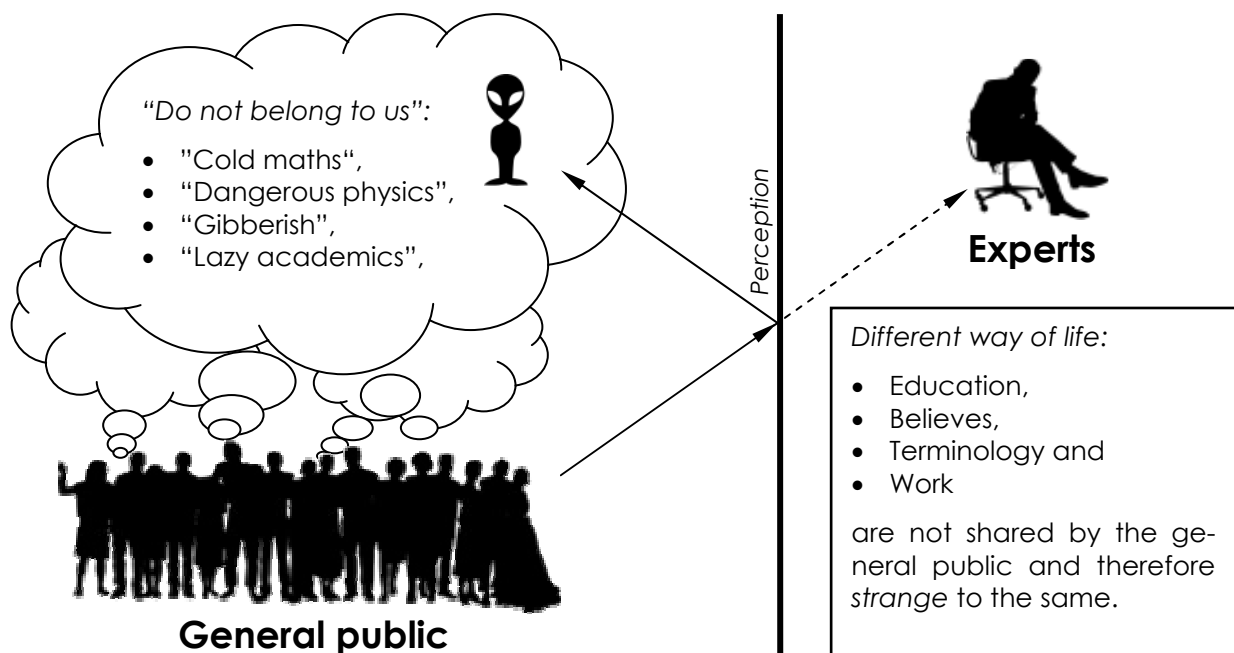


Figure 10 – Experts as an alien group due to a different way of life

much stripped of the semantic richness of their own terminology. Therefore, this is extremely boring and time consuming to an expert. The expert will most likely try to avoid this as much as possible. On the other side, the asymmetry of communication levels (see Figure 11) may be perceived as a form of arrogance or at least aloofness by the public. The public will assume that the experts were once part of the public but now lost their tracks and hence judge this in imagery similar to the metaphor of “getting on one’s high horse”. Another commonly attributed notion is the one of the “ivory tower”. This imagery is detrimental to the respect needed to perform as a technological authority.

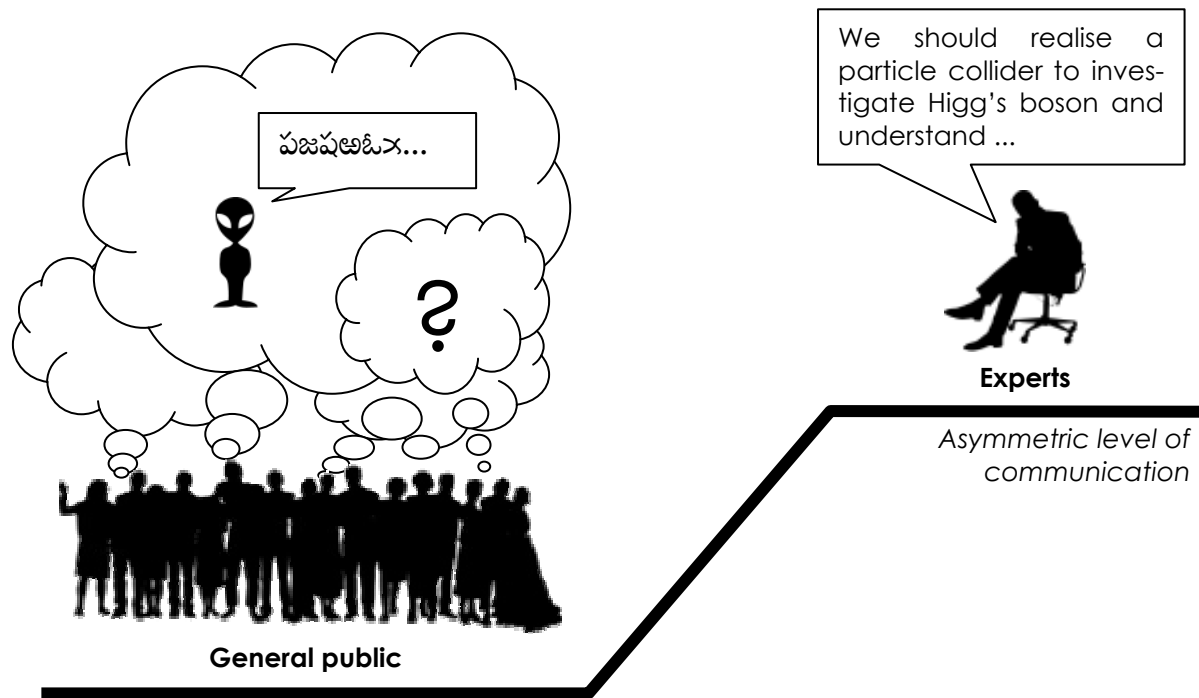


Figure 11 – Alienation of experts through asymmetry of communication

Second, many of the experts are working on their project out of conviction and according to the belief that the work is contributing to a greater good. This motivation could erode if exposed to too many questions, and the more so if critique is considered as an attack rather than as a constructive contribution. Thus, an expert will try to withdraw from such uncomfortable debates. The public will take this behaviour as voluntary secrecy and assume a hidden plan. In the example of the nuclear debate [R 7], the public is inclined to suspect the nuclear elite accepting losses among the population for the sake of higher revenue.

Third, but not reported in [R 4], the experts may prefer to stay in their own group out of perceiving groups forming the public as a social risk to themselves and out of commodity to stay in their own group. Within, special rituals, behaviour, and values – in brief: culture – will develop that are distinct from the general public’s ones. The scientific personnel especially in physics, maths and engineering are more and more addressed as “freaks”, “nerds” and “geeks”. This special culture is alienating the experts from large parts of the public not able to follow the technological progress. In consequence this leads to a public attitude of ridiculing scientific research, questioning its use and benefit and propagate other lifestyles.

The consequence of an excess of this behaviour is a reduced trustworthiness of the technical elite in the eyes of the public. The experts are inflicting impact to the main group, following both motivation and procedures non-intelligible to a majority of people, living in a special subculture

life style. From the perspective of the public, an alienated group of experts is a social risk inciting opposition against their project.

From what is understood by the date of this recommendation is that the first steps towards overcoming the risk of alienation need to be taken within both groups and should aim at reducing the asymmetry between public and technical elite. Even being as emotional and irrational as it is, it is obvious that a group can control in what extent it is perceived as a social risk through acting in a rational way intending to integrate into the and solidarise with the public. Both control loops are depicted in Figure 12, on the left, the commitment in the experts, on the right, the influence on the general public.

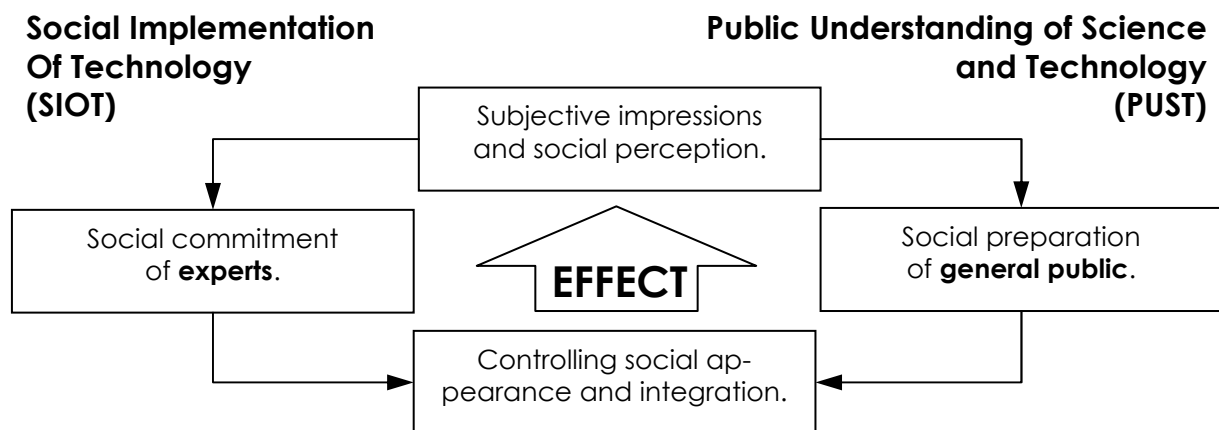


Figure 12 – Suggested progressive approach to improve the expert's solidarity among the general public.

The experts should familiarize with the concept of social implementation. They should adopt an understanding how their relation to the public is able to moderate the public acceptance of their projects through their integration into the public. The experts should become more aware about their attitudes towards the public they seek to serve by implementing the technology and accordingly analyse their own behaviour and eradicate elements leading to alienation from the public. The outcome will give interesting insight about more concrete approaches and activities to be undertaken. Also a positive stance towards debate and participation has to be adopted. This is often worded as “social commitment”.

On the other side, the public needs to be prepared in a progressive manner to be more allowing and tolerant for particular groups. This is not only a problem of sociological practice but also a cultural activity because the culture (i.e. the beliefs, the values and habits) of a society determines the threshold of tolerance. For example, a better educated society is more tolerant in general. However, the focuses of the education and its setup may or may not extend the tolerance on different types of groups. As it comes to create a better tolerance for groups involved in projects of disruptive technology, it is important to make an educational system available which both incites scientific curiosity and enables a better communication with the experts. This is calling for the experience of the Public Understanding of Science (and Technology) – brief PUS [R 5], here PUST. As PUST is relying principally on communication, it will be discussed further in the next section. In the same intention, scientific and technological jobs need to be made more attractive by the drivers of culture, i.e. media and arts. This could also make a case for economic incentives. There are many conceivable ways of enhancing the social influence of scientists which will be discussed later in the dissemination strategy.

The results of this consideration is that experts need to familiarise with the concept of the Social Implementation Of Technology. Other than learning and reading about the theory, they have to commit themselves in practice to

- Critically check their attitude and relation to the general public,
- Critically check their attitude to their project,
- Critically check their social appearance and communication,
- Diligently make according adaptations.

In order to enhance the social preparation of the public, they should implement basic social activities and activities improving the Public Understanding of Science, i.e.

- Seek the public discourse,
- Cooperate with media,
- Find ways to communicate in what way their way of life can be attractive,
- And more so, relevant for the public, and
- Offer a perspective.

These means have to be applied progressively since there is not one moment in which action and reaction will occur. There is rather a dynamic like depicted in Figure 12.

3.2. Communication

As stated above, communication plays a major key role in achieving public acceptance. In the introduction, the need of transparent and easily intelligible information about a project and its processes was indicated. In the prior section of this chapter, the concepts of social implementation and of social risk were introduced and it was pointed out that the attitudes of the expert group may affect the quality of the communication with the public. In this section, more tangible facets are discussed. First, the assumed situation of communication is described. Next, the necessary quality of the communication with reference to section 3.1 is considered with respect to an example [R 17]. Finally, available means of communication are listed.

In general, communication is a message between a sender and a receiver. In the scope of this document, it is assumed, that there is no means for the sender to verify that the message is accomplished, i.e. fully read and interpreted in a correct manner. However, estimations are possible based upon a possible response revealing the usefulness of open debate and participation. Even if communication fails to accomplish the message, the communication will affect the receiver, and this effect can also be estimated. Also, communication can succeed through various means reaching from direct verbal communication to broadcast communication through modern media. The duration of communication can range from less than a minute – in a conversation – to at least one generation – through books and education. Communication can be reflected in the Lasswell formulation: *“Who says What to Whom in What Channel with What Effect.”* This formulation is concentrated in Figure 13 on the next page. Despite not being included in this formulation, also the *“How”* is important, especially with respect to the effect.

In the present case, a model focussing on the group of experts can be established. Communication will happen among the experts and partitions of the public, namely scientific public, journalists, political elite and the general public. For the sake of considering means through which the experts can achieve public acceptance, the model sets the experts as the

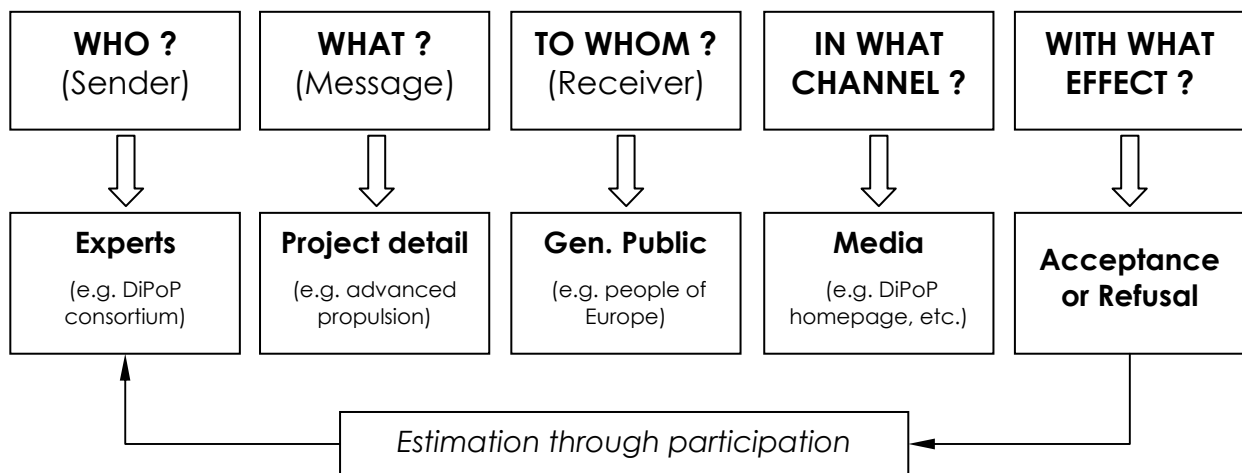


Figure 13 – Laswell's Formulation of Communication and adaptation to technological projects.

common sender of communication. The main receiver is set to be the general public for the sake of simplicity. Special consideration has to be made with other partitions of the public, such as the scientific community outside the project. The model assumes a generic channel of communication first and then derives consequences for media and education. It is used in a way as to develop strategies about the message content and delivery aiming at the desired effect of achieving public acceptance.

As described above, both a rational basis of facts and the social commitment and integration need to be communicated by the experts in order to ease positive emotions. Since the receiver is the general public in the first case and most individuals forming this group are most likely not educated to the same extent of the experts and do not generally access means of communications characteristic for the experts such as scientific journals and conferences, respective communication needs to be adapted. The first way to adapt would consist in choosing a level of language accessible to the general public. This is also concerning the way of argumentation, i.e. the “How”.

As documented in [R 17] communication on technology risks to appear “technocratic”, i.e. many conclusions are communicated to a wider public as to scientific public referring to “taken for granted” conclusion that are unknown to the general public and focussing excessively on the technological application rather than its purpose and the logic linking the solution to the problem. This is to be avoided because it may seem illogic, strange and untrustworthy, but also “incompetent” in some cases detailed and cited in [R 17]. Obviously, conclusions of common knowledge can be treated in a taken for granted way, but the experts need to understand that the common knowledge is more restricted than it may seem from analysis of scholar curricula since people are forgetful, especially about all the knowledge outside their interests. However, participating and influencing education through experts may ease this for future experts. This is why NASA is sending out her experts to any educational institution in the United States of America and this is the subject of the so called *Bodmer-Report* which introduces societal rules for the improvement of the Public Understanding of Science [R 5].

Also, the channels, i.e. the means need to be chosen as with respect to a large access among the public, i.e. newspapers, popular science books, TV journalism, internet etc. A brief assessment can be found in table 1 below. At first, it may seem rather easy to realise since interviews can be made, documentaries produced, web sites created, etc. However, there are problems of diligence, formulation and language quality related to the redaction interface between the experts and the

media recipients. In the same time, passing through media risks to be perceived as an *ex cathedra* instruction creating or augmenting a certain slope (refer to Figure 11). It can therefore distance public and experts causing the latter to be perceived as a social risk. It can be argued that a communicatively apt expert could counter these difficulties making a case for respective training. Also, maintaining as much control on the communication and degrees of liberty is useful in order to assure that the designed message has passed the redaction interface. For this approach, a thorough participation of both the redaction and the expert is needed making for considerations of the journalistic public. A similar approach of mutual participation has also to be realised towards the scientific public aiming at solidarity and a welcoming attitude when it comes to communicating proposals and offering partnerships.

Channel	Reach	Prep Phase	Participativity	Redaction	Q.o.L.
Scientific Journal	Scientific Public	Weeks or months	Direct comments, response papers	Experts, editor contribution	*** (Reference)
Newspaper	General Public	Days or weeks	Readers' letters	Journalists	*
Science book	Scientific Public	Years or decades	Review	Experts, editor	***
Education	General Public	Years or decades	Student response	Experts	***
Popular science book	General Public	Months or years	Readers' letters	Experts	**
Activity report	Politic Public, Stakeholders	Weeks or months	Direct feedback	Experts	*
Radio broadcast	General Public	Days or weeks	Letters and phone calls	Journalists	*
TV broadcast	General Public	Days or weeks	Letters and phone calls	Journalists	*
"Breaking news"	General Public	Hours or days	-	Journalists	*
Movie/Theatre...	General Public	Months or years	Letters	Playwrights, authors...	**
Mailing list	Specific	Minutes or days	Letters/Mails	Experts	****
Web site	General P., but few individuals	Days or weeks	Letters/Mails	Experts	****
Web Forums	General Public	Minutes or days	Reply postings; second best prtp.	Experts	*****
Blog	General P., but few individuals	Hours to weeks	Comments/Mails	Experts	****
Podcast	General Public	Days	Letters and phone calls	Experts	****
Social web	General Public	Minutes or days	Comments/Mails	Experts	*****
Talks and open debate	General Public	Days or weeks	Direct question	Experts	***
Direct conversation	Single individuals	Minutes or days	Conversation, best prtp.	Experts	*****

Table 1 – Channels of communication by reach, preparation phase (Prep Phase), participativity, redaction and quality of liberty (Q.o.L.).

The means of communication that should be considered encompass both short and long term communication, and both modern and classic communication. Further, newest development on the domain of communication technology should be observed. Among long term communication means there is education and schooling [R 5] aiming at raising the *Public Understanding of Science and Technology*. A good Public Understanding enables a communication on a technological level with a language with higher semantic richness than today's in order to

enhance short term communication and the competency to analyse technical data, e.g. statistics or physics. These are all addressed by the *Bodmer-Report* [R 5] commissioned by the Royal Society in London and offering well founded and practical recommendations long term recommendations concerning

- *formal education,*
- *mass media,*
- *the scientific community,*
- *casual education (public lectures, children's activities, museums and libraries) and*
- *industry.*

It should be noted that the Bodmer-Report is following a classical school of public education as previously suggested by others such as Jan Amos Komenský, René Descartes, Immanuel Kant or Alexander von Humboldt. For example it is stated within that the formal education should be broad enough to offer a significant part of the society the prerequisite to apprehend scientific basics and methodology since “science and technology permeates our daily lives” [R 5]. Thus, after introducing to the problem, it focuses on educational aspects such as subjects, the proper age for the initiation to science, the curriculum of later schooling, industrial exchanges, its funding and especially the remuneration of teachers, and finally their training. It also recommends maintaining generalisation to a certain extent in university. A lifelong learning is encouraged. In the same time, education should also aim at raising media competency in order to make people distinguish valuable and non valuable information also in order to ease the accessibility to technical data and to lower the participation threshold. While this aspect is not explicated in the text, it can be understood this way from its particular recommendation to teach statistics, which are identified to be an essential part of relevant scientific communication but badly understood by the general public and being suspected to serve as a means of manipulation by the latter [R 5].

As far as children's casual education and continued training / adult education, the report recommends that not only “resources for local libraries, and especially their scientific content, need to be sustained and encouraged” [R 5], but also to offer courses and public lectures.

The Bodmer-Report also addresses short term communication through the media and by journalists. It states that a more important presence of science in the quotidian broadcast and press is desirable. This should not only narrate the exploits of science, but also the “*human activity using biographical and dramatic approaches*” which is overlapping with the SIOT approach. It also encourages the continued training of journalists to be more understanding about science, themselves. Scientists and technological responsible are called to participate, namely to contact journalists and to prepare popular science books.

Another important actor addressed by Bodmer is industry for which the report identifies a vital interest in a good PUST. For this aim, it is suggested to enable a better permeation of management and scientific department, meaning that middle management staff should be trained technically and that scientific personnel should be given eased access to strategic posts. It also discusses in-service education and demands generically a dissemination of the industry's activities.

This is similar to the report's advice to scientists to embrace dissemination and public acceptance activities: “It is clearly a part of each scientist's professional responsibility to promote the public understanding of science” [R 5]. The report insists on this statement as it repeats it exclamatory at the very ending of the document. The subsequent set of less abstract recommendations largely

overlap with those already hinted above, among others the style of language, but it also encourages scientists to learn how to enhance the understanding of science among the political public.

The Bodmer-Report also gives very specific recommendations to the Royal Society. Some are aiming at supporting and promoting scientists engaging in PUST activities, such as prizes for both committed scientists and journalists. Others discuss the exchange between science and media; for example press services, briefings etc. The third group of recommendations focuses on the social organisation of the PUST activities' framework in the bosom of the Royal Society itself, suggesting a committee devoted to this task.

On the short term side of communication, one has to observe both media intrinsically that do enable participation (such as the web and the enhanced social web) and such that do not (such as TV and newspapers). It can be observed that the participatory media is more agile and also offers more degrees of liberty at a lower cost. It is more agile in a way in which important updates can be communicated as soon as formulated, e.g. in forums, boards, blogs, etc. This agility allows intercepting negative evolution before it can build a momentum sufficient to cause isolation of the experts. The degrees of liberties are such that text, video, podcast can be transmitted each with its respective strengths that need to be understood. For example, visual communication of an interviewee is not so strong in delivering sizeable data, however it can be very useful to display social integration through offering an insight in their motives and values. Websites collecting data can be used in a way suggested in [R 7] – disseminating project relevant information. Blogs and social media profiles can do both. However, consistency needs to be maintained.

Since experts of a concise project need to communicate with the general public in order to both disseminate information, and creating or enhancing the public understanding of their project on one side and to participate in order to fulfil their social commitment, they should embrace both long term and short term communication. This entails in general:

- Understanding how communication and various types of media work,
- Improving their language and argumentation skills,
- Taking a stance towards a larger transparency and embrace participation,
- Avoiding by all means to consider an asymmetry in language as a kind of inferiority,
- Staying aware of media development,
- Learning about the strengths and weaknesses of different means of communication,
- Allowing an insight in their personal motives and values, and
- Engaging into educational activities and interacting with journalists and others.

Communication is based both on the development of culture and of language. Therefore, it should be demanded to stay informed about recent development.

3.3. Culture and anthropology

One of the most important aspects of a project involving advanced technologies is its impact to humanity. In what way will the technology impact on human life? People's perception of this impact contributes a lot to the public acceptance of a project. For one, there is an ethical and cultural side to the impact of the project, i.e. how its consequences blend with the values of our societies. This translates in to the question: "*May we do this?*" For another, there are the anthropological consequences, i.e. the impact on humanity itself and in the ways it is distinct from *else*. The question is: "*What will it do to us?*"

The envisaged project has to be consistent to mankind's ethics and lived values. It can be taken for granted that the public will otherwise grow rejecting feelings. Such can be observed in the case of refusal of genetic manipulation and other activities affecting human life like contraception and abortion. One could argue that this is also related to the social implementation of these technologies. However, it is difficult to prove that there is public alienation to e.g. abortion. Abortion is quite easy to understand and socially well implemented. Also, the most important groups organizing opposition to it – religious groups – are not very likely to be driven by emotion which can be argued on the example of the Roman Catholic Church led by a rational elite. It is more that the implementation of abortion is not covered by the set of values supported by at least partitions of a society. This is a matter of culture, since certain values are more or less supported according to relation. More delicate subjects will cause larger portions of the society to refuse the project. Projects with subjects harmonising with the concerned public's values will find less opposition. Therefore the project needs to be ethical according to the values of the concerned public.

The impact on humanity itself is even more important. People have come to be aware that technological projects may cause changes in their lives through changes to the environment in which they live. While change in itself is neither negative nor positive but merely something different, and while many changes in man's history have been beneficial rather than detrimental, change is very often considered negative. In the past, these changes, caused by the introduction of prior "disruptive" technologies such as agriculture, led to a growth of the human population and numerous ancient innovations taken for granted in our time and which may be qualified as beneficial, and especially so to the survival of large populations. This is for example true to the Neolithic revolution which brought about agriculture. However, more recently, many changes caused through technology are perceived as dangerous to the survival of mankind. Today, it is commonly perceived by portions of the public that man deteriorates his resources through his activities. The conclusion drawn by many is to refrain from any innovation and development lest mankind will die out. Beyond this environmentalist argument, there are further anthropologic risks that are of a more socio-economic nature but that are less often addressed by the general public.

For public acceptance and solidarity, it is important to respond to this conflict between anthropological benefits and detriments of projects. The argument that technological projects generally cause anthropological detriments of environmental, social or other nature is not complete since it omits that anthropogenic means can work in both ways if not even correct prior anthropogenic detriments. For example, the fundamental of environmentalism is that man can act against or in favour of the healthiness of his biotope and that acting in favour of it is improving its ability to survive because e.g. planetary resource management has a beneficial impact if it comes to e.g. carbon dioxide and related issues. Also, on the social side, it can be found that technical revolutions like the introduction of book print contributed a lot to the enhancement of

communication. This engendered a frame for the formation of the movements of classic humanism, enlightenment and democratisation.

Further, it can be argued that realising projects encompassing disruptive approaches and technologies is human in itself and will lead to new and more advanced conditions of human living. Zubrin [R 18] wrote that space flight and other frontier activity is necessary to maintain the creative character of humanity and ensure the long term survival of mankind. According to him, the progressive formation of modern man is the consequence of previous generations' drive to extend their habitat and to enhance their living. Man made use of his intellect and ability to organise for the same and accordingly shaped his environment and the reshaped environment reformed man: In retrospective, it can be said that this enhanced man's chance of survival.

But in the same time, it must be noted, that this was not necessarily true for the concerned generations who were well equipped to survive in their environment. For them, the technological revolutions rather brought about comfort and growth. On one hand the growth manifested in larger populations. On the other hand the comfort would be understood by following generations as a basic lifestyle. Moreover, the new generation will most likely have adapted to this technology so that it assures survival. For example, a Palaeolithic population would survive with or without the comfort of Neolithic agriculture. However, a Neolithic or Bronze Age population would succumb to severe decimation if forced to rely only on hunting. This is drafted in Figure 14.

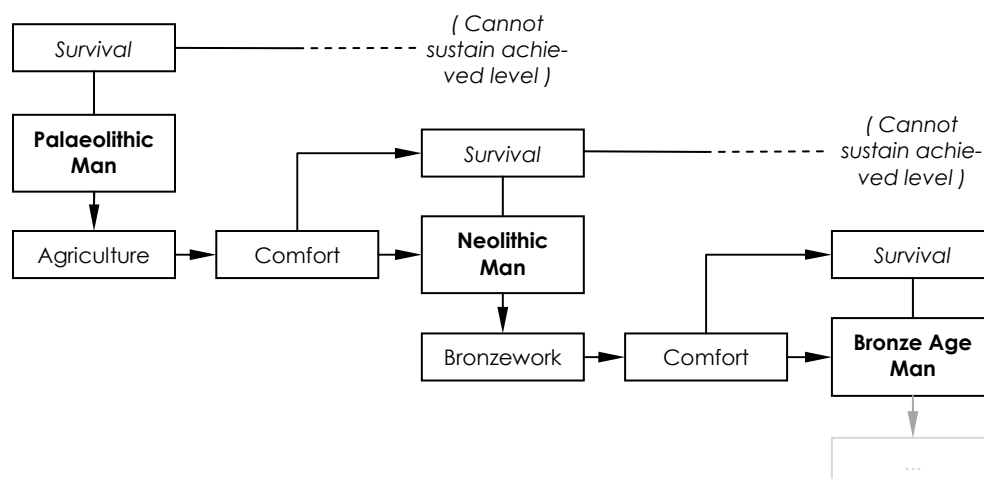


Figure 14 – Effect of technological revolution on man's survival in the example from Stone Age to Bronze Age

On one hand, this means that change will affect the posterity rather than the changing generation. This demands a certain responsibility in implementing technological projects. On one hand, risks have to be minimised so that detriments will occur extremely rarely. On the other hand, competent measures need to be taken to implement a better living.

From cultural and anthropologic considerations, two directives can be derived:

- Projects need to be ethic according to the public and therefore the experts must commit themselves to follow the development of ethics and display awareness.
- Projects can introduce game changing technologies. These can occasionally engender essentially new conditions of living. Experts have to be aware of their responsibility: It is both necessary to timely assess technologies but also to contribute.

It must be noted that the latter is a delicate demand because predictions about the future are intrinsically impossible, mere trends can be identified and uncertainties will always remain due to random events. However, for the sake of public acceptance it is necessary to deal with technology assessment issues and communicate one's perspectives since the public needs some statement of commitment as a basis for trust. This will be detailed in the upcoming two chapters.

Finally it is worthwhile to understand that human society and culture itself will have an effect to the technology in a project and appropriate it applying it in a way not necessarily intended by the experts. For example, the first air chamber tyres for bicycles were conceived as a means of comfort and respectively appraised on the market [R 19]. Since the bicycling partition of the society at this time consisted of males following an ideal of athletic and Spartan manliness and having depreciating views on comfort in sports, the tyre flopped as a product, being rejected as a device for effete people. But as soon as the same clientele discovered that the device made cycles riding faster, it became a well demanded object. It was successful as a speed enhancing device, which in turn changed the direction the technology evolved. The theory of this emergence is known as the Social Construction of Technology (SCOT) [R 19] and is reciprocating to a certain extent the SIOT approach in the sense as it considers how the public is acting on the technology's implementation rather than regarding how the experts are socially implementing the same. A better understanding of this might be interesting for a space flight project in the wake of DiPoP assuming that a timely comprehension of the direction and role a technology may pick up in a given society can enable the experts to find better decisions and the project get more momentum.

4. Technical aspects

In this section, the essential parts of the technical content of the communication needed to achieve public acceptance are considered. First, the general technological readiness of the project is addressed then the aspect of risk assessment is discussed.

4.1. Technological readiness and feasibility

Informing the public about a technological project needs to enable transparency on both the technological background and available technical data. Public acceptance is more likely to be achieved if the public considers the used technologies controllable and well understood, which is making the case for the question of technological readiness. This is addressed in the present section considering the general public.

Reconsidering the case example of Stuttgart 21 [R 13] in section 2.3 and considering public opinion about nuclear fusion power in e.g. Germany [R 7] or Apollo denialists, one will find that individuals among the general public may oppose following their own technological judgement based on “knowledge”. In the prior sections, a case was made that this is a social reaction answering mistrust in the experts. However, since this is also extending to the scientific public outside the projects, there is a second dimension to it which is content related. In the three mentioned cases, opposing individuals tend to think that they have a knowledge peer to the knowledge of educated and experienced specialists while this is not true from an objective point of view. The lack of education not only contributes to an asymmetry of language between but also to an asymmetry understanding or knowledge; the public has partial understanding and the experts have specialist understanding (Figure 15). In this respect, claiming to have knowledge peer to the experts’ one is not only a rationalisation of mistrust against others, but also a statement of excessive confidence in one’s own information and completeness of one’s own education. That the deficit of knowledge and understanding risking the loss of acceptance of technological projects and the loss of solidarity towards experts was also detected in the Bodmer-Report [R 5] where this mechanism was introduced as a *deficit model*.

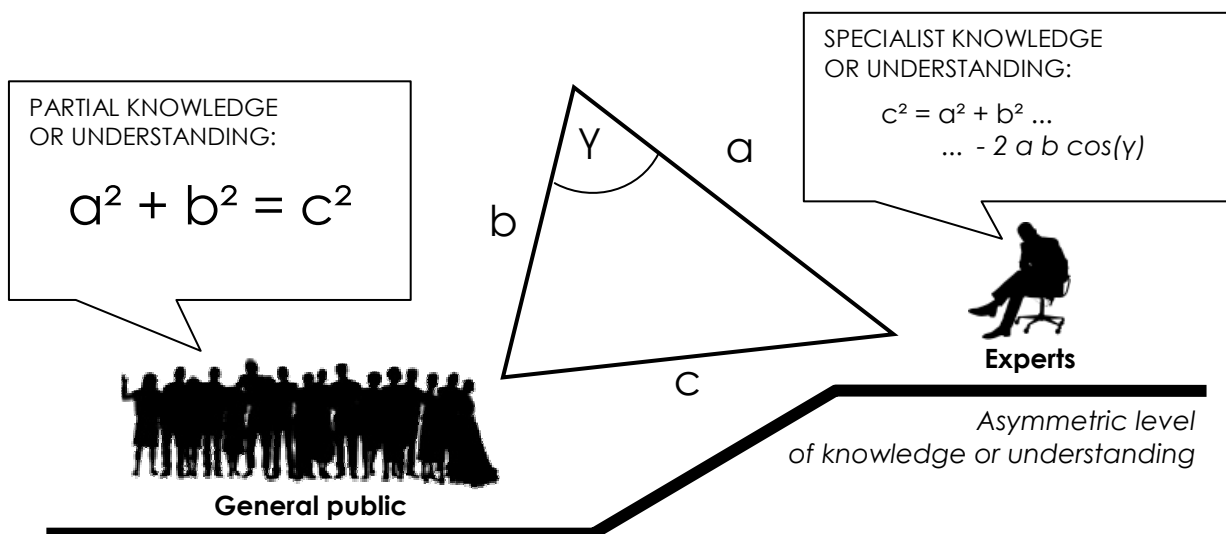


Figure 15 – Partial and specialist knowledge or understanding on the example of the general Pythagorean Theorem

Overestimating one's own partial understanding can obviously affect people who abandoned the natural scientific/technical education after school, such as scholars of humanities, economics and life sciences. But it can also affect people who did not leave the natural scientific/technical curriculum after school and who therefore have a really good insight in similar but different technologies or sciences, like experts of other disciplines.

The various disciplines of engineering developed due to the growth of engineering knowledge in the past centuries. Different branches specialised more on particular problems and their solution while they neglected to consider those of others. This can lead to a certain level of mutual ignorance. For example, a civil engineer of construction is not very likely to understand electronics engineering and an electronics engineer will have less insight in the hydrostatics of concrete. However, both will have a common foundation of maths and physics and may question each others' expertise drawing upon on it and not being aware that the other may have approaches that run deeper.

In both modes, the partial knowledge is mistakenly considered for the maximum available knowledge by the affected individuals. This is due to an unaware overestimation of one's own capabilities. This is human and has to be taken for given. There is no conceivable way to deal with it except patience and communication aiming at sharing knowledge and convincing on technical grounds. Obviously, this is the crucial case for the Public Understanding of Science and Technology approach as introduced by the Bodmer-Report [R 5] and recapitulated in section 3.2.

Further, if the opportunity to communicate is omitted by the experts and taken by a minority with partial understanding, their opinion and judgement will be adopted by the public and become very difficult to rectify.

From this reflection it can be said that the experts need to disclose their knowledge and reasoning from the beginning and that their communication on technological readiness needs to fulfil the following three functions:

- Deliver the necessary technological or scientific background,
- Provide an intelligible and well documented database on the project,
- Describe alternatives and approaches to work around particularly hard issues.

The delivery of the technological background is essential in order to achieve a public being able to discuss the project competently. It will enable the individuals among the general public who already have a positive stance on the project from the beginning to convince those who are not. It will also enable them to identify unserious reasoning based on half knowledge. On the social way, it will reduce the risk of asymmetric communication with the experts. But for the sake of communicating technical data, it will enable the public to digest the provided database.

The database needs to provide full information and transparency and should help the general public understand the experts and ease the participation. Therefore special diligence has to be spend on the general quality of the implementation. The creator of the database has to be aware that the general public is not familiar to units and numbers' formats proper to databases, statistics etc. Also number columns are not very intelligible to large portions of a population even of a nation considered to be a "knowledge society". The interface needs to be carved accordingly.

The database should support the reasoning of the project's proponents. But in the same time it must neither ignore facts that may be interpreted in favour of opponents nor conceal drawbacks. If one of these flaws was found in the database its reliability and the public's trust in the experts

may be seriously degraded (cf. section 3) which would endanger the project even if its benefits outnumbered the drawbacks and even if the problems were easy to mitigate.

It is rather up to the experts responsible for the project to expose the chain of thought that lead to the proposed project decisions and to explain the reflection. The transparency of the development can reduce the distance between the experts and the general public and hence the risk of refusal by the latter. The same effect can also be achieved by the experts showing awareness about the public's issues and the displaying adaptability and monitoring the general progress. For example, the used technologies levels need to be reassessed on a regular basis and especially in case of more disruptive or advanced approaches proven by proofs of concept well communicated to the general public, e.g. through online videos.

Also, in case of delays it should be exposed, that there are options for a workaround to avoid a complete project stop due to a single point failure.

A related, yet special question is the technology's safety and consequences. This should be of a particular concern to the experts. They should disclose in their communication that they are aware of risks and reassess the technology's controllability on a regular basis. Experts should also make the technology's proofs of qualification and of risk assessment accessible.

4.2. Safety aspects of disruptive technology and commitment

Environmental and moreover safety aspects are vital for the public acceptance of a project. It is very unlikely to achieve public acceptance if a technology called in a project is taken for unsafe or unevenly risky. This can be observed in the dominant reasoning of the anti nuclear movement in Germany [R 7]. The impression of two nuclear catastrophes – one in Chernobyl, the other in Fukushima – scared the public of a potential repetition.

Despite the risk being negligible compared to other human activities, the impression of two nuclear catastrophes – one in Chernobyl, the other in Fukushima – incited a fear of radiation driving the society out of this technology. In retrospective, the lack of transparency in both cases and the perceived difficulties in mitigating the incidents one side and the asymmetry between the overly optimistic safety claims of experts and the perceived dramatic magnitude of the catastrophes on the other side can be identified as the main driver in the public reaction. On the technological side, the German public interpreted both events such as the technology could cause severe threats to their live and health, such as incidents may happen rather often despite the claimed infallibility of the technology, such as there was no plan how to deal with a reactor crash.

Accordingly, *the first lesson* to be learnt is that the approach to achieve public acceptance by downplaying safety risks will likely lead to an overwhelming refusal of a project, in post. The public will righteously feel deceived and by the logic of the perpetual liar not trust the respective group of responsible again. Consequently the solidarity will be withdrawn to an extend making it almost impossible to individuals of this group to start any further project. *The second* is that all safety assessment needs to encompass strategies to mitigate incidents and that these strategies need to be implemented consequently. This is because a zero risk is impossible. Even the best engineering approach may contain some unfound error leading to serious incidents. Also, good engineering cannot avoid human error or –in the worst case – abuse. The consciousness about this condition also needs to be raised among the public, alongside why the risk in question is worth it. Especially, the public's fear of being delivered to serious or catastrophic modes has to

be responded. This can be done by defining rules of responsibility. In the case of domestic fires, for example, there is a whole chain of responsibilities involved in the mitigation: The person noticing the fire has to phone a control office triggering the counter process. It will then address the nearest available fire brigade and hand over the information obtained from the altering individual as for example the address of the fire. The brigade itself will put an end to the fire as trained. The fact that this role model is well understood and trusted makes fire related risks more acceptable to the general public as it does not feel too delivered to them. On the other side, respective role models were not sufficiently developed in the case of both nuclear averages pointed out above: In the case of Chernobyl, the government had to draft the liquidators from scratch while in Fukushima the fire brigade appeared not prepared enough to mitigate the incident [R 20]. *The third lesson* is that the experts need to have a risk awareness of their own and are urgently needed to be transparent about their activity. This is related to large extends to the beliefs which make them special from the general public, in particular the belief in safety and sustainability. Discussing these issues with outsiders or allowing transparency creates a motivation for a diligent continued assessment of risks and fuels the process of improving means of safety and mitigation. It also assures the control chain which appeared to be too fragile in the Fukushima event. There, it the control was circumvented due to a lack in transparency paired with overestimation of the safety aspect [R 20].

Since the DiPoP project focuses on enhanced power and propulsion for application in space, for example exploration beyond Mars, it will consider nuclear power sources. As already raised above, there are safety and environment issues that these bring along and that should be addressed ab initio. In the following, the internationally agreed framework for nuclear systems in space for a minimum risk assessment and mitigation approach is outlined and presented. Communicating the general safety framework to the general public can increase public acceptance since awareness about the underlying legislation and its legitimisation adds to the confidence that the expert work is supported by a third party which is not part of the project proponents and which is composed of scientific public and representatives of the general public.

4.2.1. Safety framework considerations

The safety framework which needs to be adopted for nuclear power considerations in DiPoP derives from international legislation by the United Nations' (UN) General Assembly [R 21] and is developed by the Scientific and Technical Subcommittee of the United Nations' Committee on the Peaceful Uses of Outer Space (UN COPUOS) [R 22]. Besides its adoption by the UN COPUOS member states it was also adopted by the IAEA member states [R 23]. In its form and overall content it has been developed in consistency with form and language of the IAEA safety fundamentals. The ENSAF process is the implementation process of the respective safety at an ESA level [R 24 – 26]. The hierarchy of these settlements go from very high level documents with a rather general scope to documents more and more particular in both their range of application and level of detail. This hierarchisation is depicted in the Figure 16.

The General Assembly recognizes in [R 21] both that space is a common resource for the whole humanity and that Nuclear Power Sources (NPS) or other nuclear space systems can be vital for the human utilisation of space in general and the solar system in particular. Examples are depicted in Figure 17 on the next page. The General Assembly also recognizes safety aspects relevant to NPS and recommends focusing their application to cases in which they are



Figure 16 – Hierarchy of safety principles and frameworks (exemplarily)

advantageous, and demands a restriction to missions that cannot be reasonably operated without NPS. The General Assembly also demands a thorough safety assessment and risk analysis and defines respective guidelines and criteria.

The main goal of these is to prevent any harm emerging from NPS to human individuals and therefore also their environment according to definitions made by the International Commission on Radiological Protection, targeting at an average radiation dose of 1mSv/a over a lifetime with an allowed peak of 5 mSv/a.

From this demand, [R 21] derives a set of design recommendations on the system hardware like shielding, on the system operation, like orbit design such as only certain geographic areas may be concerned upon re-entry and such as system start-up conditions (cf. Figure 18). Also contingencies are considered, such as launch failure or un-controlled re-entry. Reactors and radioisotope subsystems are considered in depth.

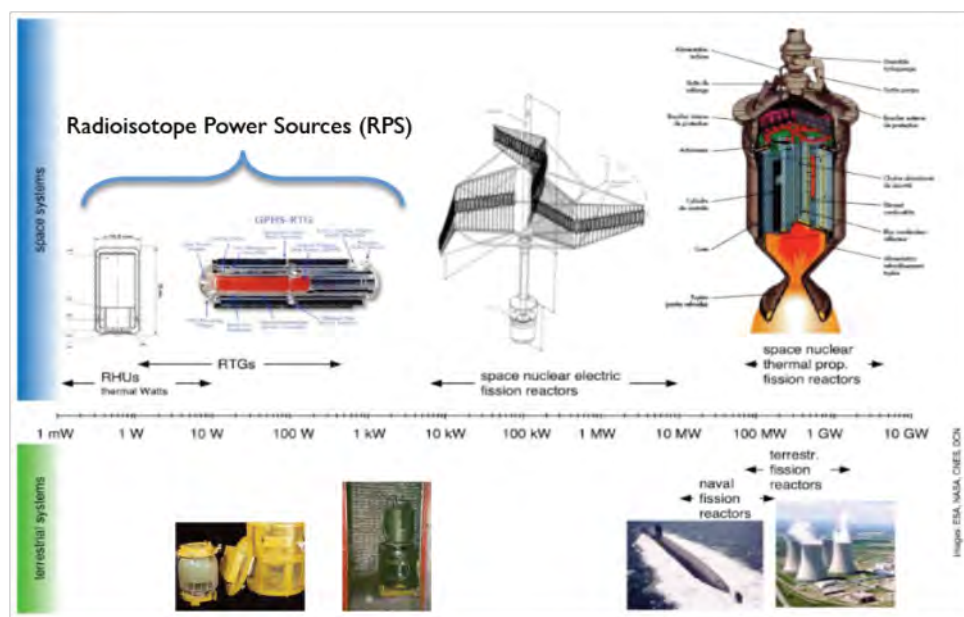


Figure 17 – Examples for nuclear power systems in space and terrestrial comparison [R 26].

To be more precise on the guidance to fulfil this aims, the treaty settles that a safety assessment covering each mission phase and each subsystem and piece of equipment must be conducted by the states participating in a project. The treaty also demands that relevant information is shared, above all in the case of uncontrolled re-entry. In this case, all relevant data concerning the space craft and the NPS should be disclosed to all countries occupying potentially affected territory and the Secretary-General of the UN as soon as a contingency is detected. International participation in the respective communication must be enabled and questions answered. Concerned states must be assisted by the state responsible for the incident. The state's responsibility, and with it its liability, also extends to non-governmental corporations.

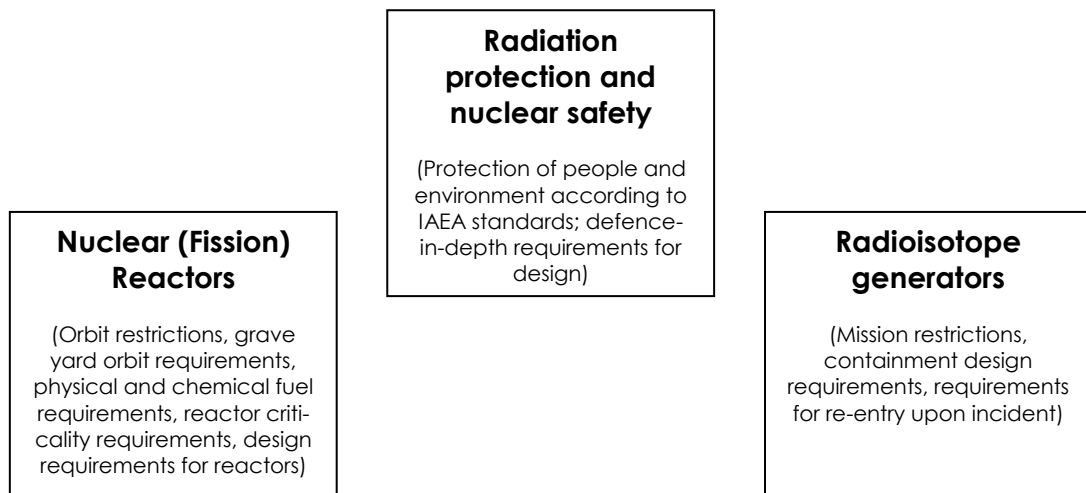


Figure 18 – Technical safety aspects according to international space law [R 21]

The treaty [R 21] settles that disputes must be resolved in peaceful negotiations. From this, the has developed the high level *Safety Framework for Nuclear Power Source Applications in Outer Space* [R 22] in cooperation with the International Atomic Energy Agency (IAEA). This document precises the principle worded in [R 21] for (the responsibilities of) government, management and technology. Above that, this document aims at reassuring the public that NPS will be used in a safe manner and facilitating multilateral cooperation on space missions. The framework explicates that being top level itself the detailed implementation of its guidance will depend on the particular case. It names the terrestrial installations needed as an example and states that the respective norms and standards for terrestrial nuclear installations shall be applied to those for the sake of fulfilling the principles of [R 21]. The framework is also restricted to the protection of individuals on Earth.

According to this framework, governments – and thus public bodies – as a regulating organ shall establish safety policies to regulate the use of NPS, shall check the design justification for missions and spacecraft bearing NPS, and shall govern and apply a suitable mission launch protocol. Above that, these bodies must prepare and exercise contingency mitigation strategies and processes.

The management in its sense as the executing and project running entity shall maintain the primary safety responsibility. This means that it shall enact instruments and processes to fulfil the governmental policies. The management shall, among others see to the technical realisation of safety, respective training throughout the process of project conception, realisation and operation of the product. The management must enable due transparency and participation

through consideration of opponents' arguments. The establishment of a safety culture within the management is stipulated.

On the technical side, the framework demands to acquire the necessary safety competence, encompassing studies of emergency, assessment of consequences, identification of necessary safety features, realisation of the safety competence during the design and development function of the project, extending from production of the NPS elements to the operation and, finally, deposition of the respective craft. Also, the technical staff shall conduct risk analysis to estimate the impact of any accident to the objective defined in [R 21] and devise strategies and approaches to mitigate consequences.

One can consider the tasks of the management and the technical staff to be the most decisive safety relevant activities in the realisation of projects bearing spatial NPS. It is therefore important to communicate respective information to the public in a transparent and intelligible manner to assure the public that undue risks are excluded and the remaining risk is manageable.

The framework is being adapted to the European situation yielding the European Space Nuclear Safety Framework ENSaF [R 24 – 26] which will be the most important documents to consider for DiPoP which is a European project. With these, Europe defines its stance towards NPS for space activities. The documents are based upon the international legislation and framework described above, and upon European safety standards and procedures given by EURATOM using IAEA directives, and encompassing industrial experience, and upon standards and procedures from experienced partners, namely the United States of America [R 27, 28] and the Russian Federation.

The current draft of ENSaF stipulates the establishment of a process to approve the launch of space craft with NPS and considers the necessary organisation and role model of the executing body, the minimum design requirements, provides guidance for the estimation of launch risk and develops respective contingency mitigation scenarios and strategies for the dissemination of necessary information. If the necessary conditions are met, launch will be allowed.

4.2.2. Exemplary application of safety frameworks

In this section, an exemplary application of a hypothetical nuclear safety framework is presented. First, an initial design is drafted. Then possible events during a simple and fundamental lifetime of space borne nuclear reactors are lined out and concentrated in Figure 19 on the following page.

4.2.2.1. Proposed initial design

The reactor description at the beginning of the study could be based on an existing design like TOPAZ even if the conversion system may be different. Values of the TOPAZ reactor are collected in table 2. For example, a Brayton machine may be installed instead of a system of thermo ionic diodes. This could be useful to analyse the impact of an accident like a launch failure on the integrity of the reactor vessel and the behaviour of nuclear fuel in case of reactor breakup during re-entry. The reactor description could be modified to adapt to the reactor design resulting from the study and re-injected in the safety analysis. Further, instead of fuel pins some space nuclear reactor designs stipulate a prismatic carbon matrix containing uranium oxide particles coated with layers of silicon carbide and pyrolytic carbon. These systems are called BISO or TRISO. Also, a Small Nuclear Generator (SNUG) design might be used as a starting model as well as Pin-Type Gas Cooled Reactors such as proposed by Sandia labs.

Already at this stage, a radiologic assessment of the nuclear fuel may be conducted. For example, the radiation yielded by a TOPAZ reactor mainly coming from the Uranium, is initially at about $2 \cdot 10^9$ Bq which is about thousand times more important than the natural radiation yielded by a human body. On the other hand, the Cassini RTG based upon Plutonium had with $1.5 \cdot 10^{16}$ Bq a far more important initial radiation.

Parameter	Value
Thermal power	135 kW
Electrical Power	30 kW
Fuel mass and type	27 kg UO ₂ , enriched to 96 %
Oxide pellets size	9 mm dia. 9 mm long
Moderator	ZrH
Total mass	1000 kg (without radiator)
Initial reactor activity	$2 \cdot 10^9$ Bq (mostly from U 235).

Table 2 – Topaz 2 characteristics

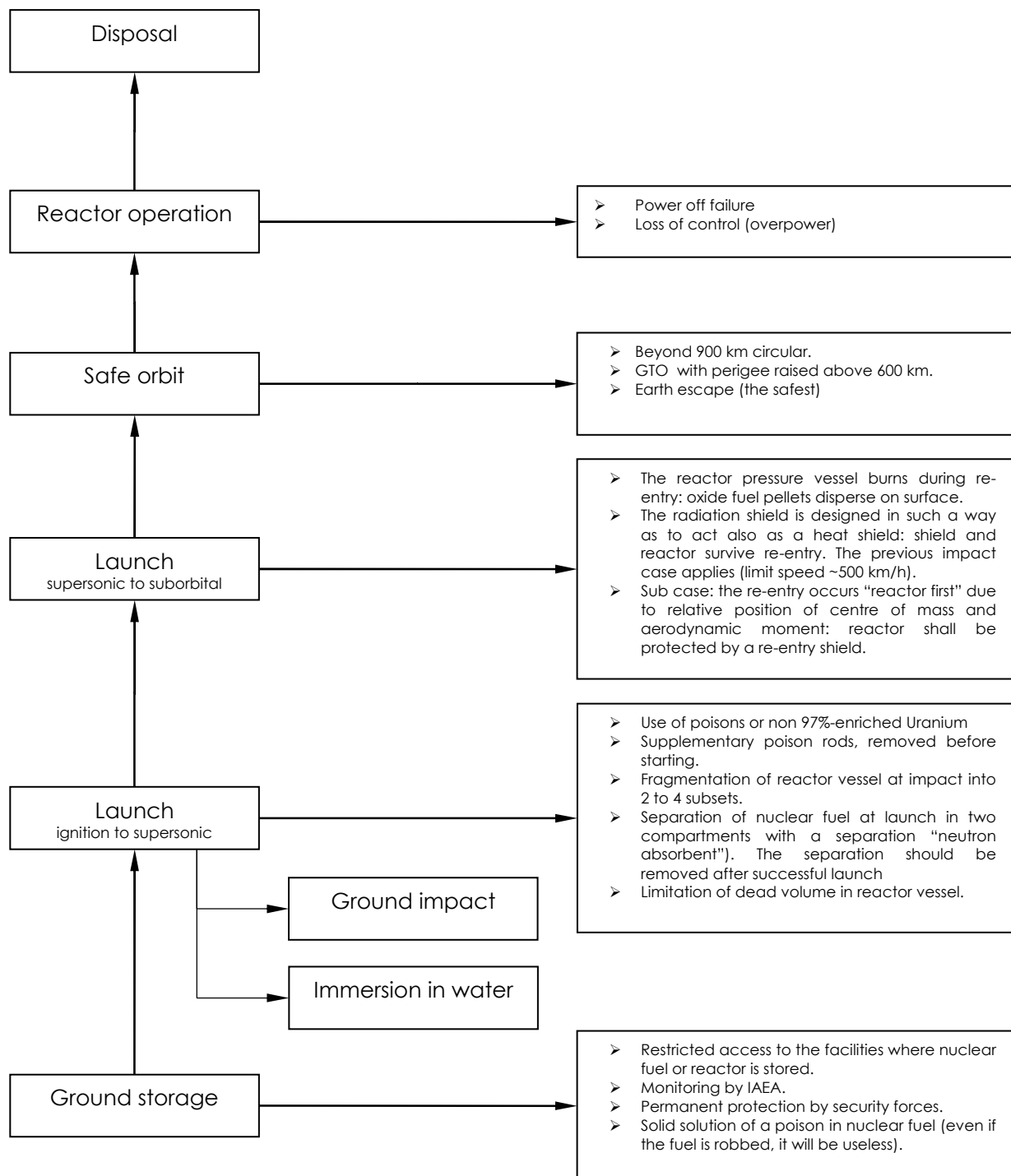


Figure 19 – Generic lifetime events of space borne nuclear reactors

4.2.2.2. Reactor lifetime events prior to orbit injection

A fundamental lifetime of a space borne nuclear reactor will begin with its *integration and storage*, follow up its *launch* and *operation* and end with its *ultimate disposal in space*.

In the *ground storage period*, both criticality accidents and dissemination have to be prevented. During storage, the nuclear fuel shall be kept in separate containers in order to avoid the accidental formation of a critical mass. If possible, these containers should be coated with or made out of a neutron deflecting material.

Other than risking unintended criticality, the highly enriched uranium oxide could be *stolen* to produce a nuclear weapon of mass destruction (WMD). To avoid that, a layered approach is recommended: First, the access to the facilities where nuclear fuel or reactor is stored must be restricted to cleared personnel monitored by IAEA. The facility must be permanently guarded by reliable security forces. Second, the nuclear fuel must be made useless to abuse or extraction. This may be achieved through adding a solid solution of a poison to the nuclear fuel. Such poisons are also useful to limit the excursion of reactivity during the reactor life while fission products build up and to prevent accidental reactor starting through immersion. This approach is roughly similar to the one for nuclear fuel from decommissioned nuclear weapons. Up to now, these measures seem efficient.

The *launch* of the vehicle can be divided into two distinct regimes. The first part is the regime following up the *ignition of the launcher rocket* and ranging to its *transition into the supersonic flight*. The second is the regime from that moment to the *suborbital injection to orbit*. For a European mission encompassing a full capacity geostationary transfer injection, a launch from Kourou aboard an ARIANE 5 ECA or ARIANE 5 ME is assumed. The main stage (EPC) is normally dropped above the Atlantic Ocean and the upper stage is ejected in orbit.

If a failure occurs during the first regime of the launch, there can be two possibilities for an impact of the payload. It can drop either on the “dry” ground or into the Atlantic Ocean. The payload may disintegrate, however the reactor and its shield have to remain intact. Gas lines linking it to the radiator will be either damaged or severed if the payload disintegrates. The reactor vessel and its shield will reach an impact speed of almost 500 km/h which is the limit free fall speed.

Experience from ARIANE 5 launch failures, shows that massive objects like VULCAIN turbopumps will survive an impact in the *mangroves* near Kourou without major damage. It is therefore proposed that the most probable case consists in the reactor vessel remaining intact upon impact but with possible intrusion of water or mud.

However, it cannot be ruled out that the *impact on a hard surface* like a rock may occur. For example the reactor can drop on the “*Iles du Salut*” or on a building of launch facility. For this case, a possible strong deformation of reactor vessel must be analysed. Designs should result in a breakup into three or four parts can be considered for the sake of avoiding criticality through geometry. Another approach is to reinforce the pressure vessel of the nuclear reactor. Bearing in mind that the reactor diameter is close to 300 mm and the mass of reactor and shield weighs about 500 kg, the ballistic coefficient could be sufficient to allow a penetration of concrete and stone without causing major deformation, provided that the pressure vessel is sufficiently strong, that the nuclear fuel has a high mechanical resistance and dead volumes are filled with buffer

materials like carbon or carbon composites. Recent FEM models taking into account plastic deformation may help to determine the survivability after the impact. If the penetration depth is 1 m, the expectable mean deceleration amounts to about 10000 m/s^2 and the mean stress in the 30 cm section is approximately 70 MPa.

If the reactor is *dropped above the ocean*, other considerations apply. It is known that an immersion in water could render the reactor critical, especially if a fast neutron reactor is used. Water which is a good moderator may flood the space reserved to the gas circulation. The most probable scenario is a repeating cycle of progressive water intrusion into the reactor vessel until its criticality limit is reached. Then a massive water boil-off due to the reactor heat occurs that leads to an interruption of the chain reaction before further water can intrude into the volumes leading raising criticality again and so on. One risk is to have the fuel sheets corroded by salty steam and liberating volatile fission products into the ocean. Due to the trajectory from Kourou, an immersion accident is the most likely among the accident cases. It should be therefore carefully analysed. A list of measures to prevent criticality events upon immersion is given in table 3 beneath. For a rapid recuperation of the reactor, it should be equipped with beacons.

Use of poisons or use of non 97% enriched Uranium (<20% only)
Supplementary poison rods, removed before starting.
Fragmentation of reactor vessel at impact into 2 to 4 subsets.
Separation of nuclear fuel at launch in two compartments with a separation "neutron absorbent").
The separation should be removed after successful launch
Limitation of dead volume in reactor vessel.

Table 3 – Various measures to prevent criticality by immersion

Once the *hypersonic regime is reached*, an accidental re-entry may induce a partial burn-up of the payload. The assumption is that under aerodynamic forces and heat flux, reactor / shield assembly will likely separate from turbo machinery and radiator yielding two cases. For one, the reactor pressure vessel burns up, too. This will disperse oxide fuel pellets above the surface. For another, the radiation shield is designed in such a way as to act also as a heat shield so that the reactor survives the re-entry. In this second case, the previous impact case applies again, since the impact speed is limited to about 500 km/h. However, it is thinkable that the re-entry occurs "reactor first" due to relative position of centre of mass and aerodynamic moment. Therefore, the reactor shall be protected by a proper re-entry shield.

Some previous reactor designs involve a pyrotechnic destruction of the reactor vessel before ground impact in case of launch failure in order to prevent criticality accidents. This option should be exerted with caution. The pyrotechnic devices are certainly resistant to natural radiations from uranium but not from radiations and neutrons from an operating reactor. The explosion may occur during the nominal operation in space and cause the loss of the mission. If the pyrotechnic destruction is chosen, the pyrotechnic device should be jettisoned before the first time the reactor goes nominally critical.

4.2.2.3. Reactor lifetime events after orbit injection

After a successful launch, the reactor has to reach the *safe orbit*. The reactor start up shall not be allowed under an altitude providing a natural re-entry at least 100 years after a failed attempt. The initial orbit could be at a height beyond 900 km. It should be circular. Also geostationary transfer orbits with an elevated perigee at about 600 km are thinkable. The safest, however, was to inject the vehicle directly into an escape trajectory. In the following *operative phase*, possible failure modes are numerous, but they can be narrowed to a few “major” cases encompassing a *power off failure* and a *loss of control* resulting in overpower.

As for a *power off failure* the case includes a number of sub cases like the loss of control drums, the loss of activity due to a reactor poisoning by fission products, the loss of coolant gas, and the main and redundant turbo alternator failure. In all cases, the result is that the spacecraft is stranded in orbit. A chemical propulsion module could be used to reach a “safer” orbit for the disposal of the lost vehicle.

The power off failure mode can be prevented through:

- Redundant turbo alternators and electronics.
- Provisions to compensate fluid loss from small leaks.
- Reactor designed with activity margin.
- High reliability of control mechanisms.
- Independent control for chemical propulsion module in order to allow module control even in the event of total lack of nuclear generated electrical power.

A *loss of control (overpower)* can result from several causes. For example, the control drums can block, or a thermal runaway may occur. It is proposed to prevent this failure mode through having a negative reactor temperature coefficient preventing the thermal runaway. Also, the reactor should be controllable during its whole life with only one control drum fully open. Still, a high reliability of control mechanisms needs to be granted.

In case of *early failure in Earth orbit* it is recommended to provide a small chemical module able to inject the failed spacecraft on a safer orbit as previously discussed. The small chemical module could also be used for the nominal scientific mission (e. g. capture around the target).

A *reactor failure in interplanetary space* will effectively result in the loss of the mission. In order to avoid the unwanted hyperbolic re-entry to Earth from an interplanetary space, it is recommended to eliminate mission's profiles involving Earth swing-by manoeuvres with a reactor already operating. Earth swing-by with dormant (un-started) reactor might be used, but this mission profile is unlikely.

If the spacecraft is orbited around a celestial body like Europe or Ganymede where sub-ice oceans are suspected to exist (and possibly harbour life) it is recommended at least to raise the final orbit around this body, so surface impact cannot occur before some hundred years. This is an issue of planetary protection. Escaping the gravity well of the celestial body after mission would be better, but could be impractical in terms of ΔV .

Eventually, the nuclear equipped spacecraft has to be *ultimately disposed*. Extremely high graveyard orbits may be thinkable or circular orbits around the sun.

5. Economical aspects

5.1. Overview

Technological projects are in general also economic ventures. This is due to the fact that capital needs to be enacted for planning and realisation. The experts need to be paid, external studies and services acquired, hardware for production (ranging from computers for the design of the project) and raw materials needs to be bought. This can lead to a considerable investment. Funding can be allocated in various ways: Public funding, starter credits, shares, etc. As for the economic benefit of a project, also various ways of balancing the funding can be found. For example, a direct return consisting in products and services issuing from the project. On the other hand, there's an indirect return that can be more interesting in many cases, consisting in expertise, knowledge, spin off to other industries or domains.

If it comes to the public acceptance of a project, the balance of funding and return needs to be observed diligently. The way the public perceives the experts does not only depend on the aspect described above, but also on their economic aptitude. If the general public perceives the balance to be sufficiently negative, i.e. the funding surmounts the return the acceptance for the project and its follow ups and similar projects will degrade and erode. As also in prior facets this perception may not be based on fact but rather on impression opening an interface to the communicative and social field. It is important to communicate the project's return to the general wealth of the public and this with a special regard towards transparency and social implementation of the expert groups and its partners.

Also, special considerations need to be made with respect to special public like stakeholders and other elites. There is a real competition among fundraisers from different domains and in addition to that, there can be a virtual competition among projects which cannot be funded from the same source. An example for this is the anti Stuttgart 21 argument that the reconstruction of new station gulps the funding of education and health care while in fact the infrastructural means are not available for these items.

5.2. Facing general public

The economic side of public acceptance towards the general public can be found to be highly dependent on the communication. The general public will observe the expenses of larger projects with respect to three aspects: Justification by appropriateness of the funding, risk of fraud, and justification by merit. Also, there is the crucial problem of liability which concerns the costs of technical and environmental risks.

Observing the public debate about Stuttgart 21 and other projects, suspecting fraud or corruption can be identified as one of the main drivers of opposing attitudes. The general public is concerned about the fulfilment of its values and norms by project executives and political or financial elite. Further, it tends to understand itself as the general victim of any criminal business practice and this point of view is amplified in the case of publicly funded ventures, and even more, if a consortium of private enterprises is engaged in these. This attitude is independent of the actual behaviour of the executives – in the scope of this document, an impeccable business ethics among the project experts and political elite is taken for granted. This askance attitude does not necessarily arise from a reasonable ground for suspecting or proof. Suspicion can

already arise if room is left for speculation, that is, if there is a lack in transparency concerning the funding and the decision process behind the funding. Again, it can be concluded that transparency and good communication are necessary to achieve public acceptance. Also, the experts shall allow for participation in order to be observably responding to any inquisitiveness concerning their funding.

The general public's acceptance of the funding of a technological project will also depend strongly on the economic justification and on the appropriateness of the funding especially with respect to apparently competing alternative ventures to fund out of the apparent same origin. The public debate about space flight is in general accompanied by arguments questioning why so much public funding was used for such a "vain" adventure in space, while there remain so many problems on Earth. A balance is made between expenses serving many – especially miserable – people and expenses serving a few or no one. This widely accepted point of view can be qualified as a polemic. It is based on asymmetric information and awareness as drafted in Figure 20. In the same time, people are more aware and made aware about the extent of budget cuts in education, healthcare, development support and catastrophe mitigation than about the portions of their budget and absolute numbers. And in the same time, people are more aware and made aware about the costs of space flight and its social alienated allures than about the daily life use of space flight, its benefit to the society and its comparably low cost.

It is therefore necessary to pay special attention to communicating the appropriateness of the funding in a way to soften the information asymmetry, to disclose the origin of the funding and its extent in absolute and relative numbers compared to other budget items and to name alternatively funded projects.

Further, there is a need to justify the expenses for technological projects such as space flight by merit. Space flight always needed to defend its right to exist against short reach utilitarian

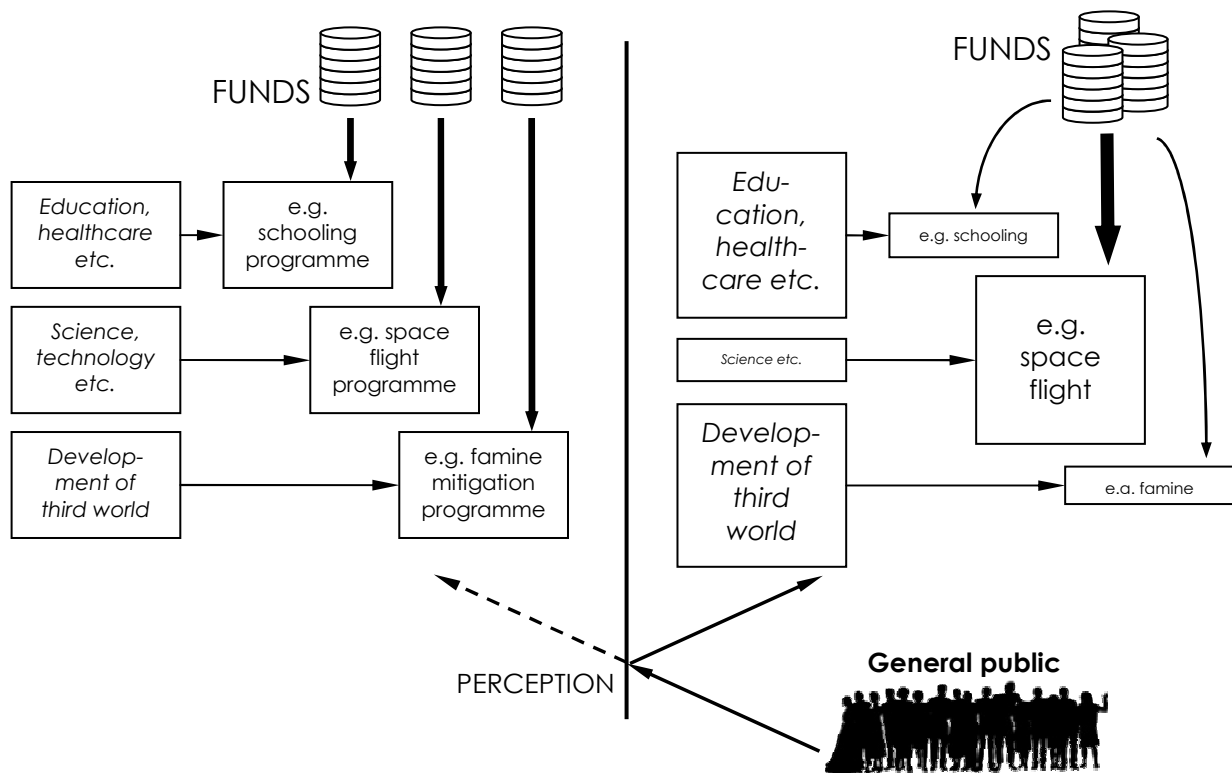


Figure 20 – Asymmetry in the awareness of public funding

argumentation. This can be observed in debates on whether to fund space flight in particular. Large portions of the general public claim that space flight was obsolete since there is no terrestrial use to it while there is also no point in going to space itself. On the other hand, there are plenty of examples in which space borne systems support vitally terrestrial services and systems like satellite communication; there are also examples in which a development made for space flight was spun off to terrestrial problems and engendered a considerable leap ahead, like micro electronics involved in Apollo missions. Nowadays, losing space borne support would cause huge economic damage to many businesses, to observation etc. Socially conveniently paid high performance jobs in the space industry can create competencies and push the state of the art further. This enables emerging experts to solve other problems in a more efficient and more creative way trained on exigent space flight requirements. Albeit often underestimated, space flight is a cornerstone of our modern technical civilisation. Similar can be argued for space exploration programmes.

All of this is however unknown to many people in Europe. Making an experience in asking random people on the public transportation about what they knew about space flight and its application will give an appalling insight. This is different in the United States of America where the public is slightly better informed due to the communication and public relations strategy of NASA. A similar approach should be followed in Europe. Experts should take an initiative to disseminate the information about the benefit of space flight.

Beyond the issues of business practices, funding and return, there is the question of liability. This final and maybe most important question arises from the costs of technological and environmental risks – i.e. incidents and pollution – entailed by a project which is similar to the question of responsibility and roles among the technical aspects. Reading German press on arguments for the abandonment of nuclear power with respect to reasons beyond the fear of radiation reveals that the public tends to perceive this technology's benefit relying largely on the undue externalisation of costs related to accident mitigation – if applicable – and in particular to the nuclear waste management. It is often stated that the respective costs for the disposal are not paid for by the operating companies and rather being provided for by the public. It is also said that in case of a real accident entailing the contamination of some area, the mitigation and decontamination would also be disbursed by the tax payer instead of the operator who is generally considered to have failed in such a case. The opinion goes as far as to claim that they had bagged the income from the electricity consumption while unethically stealing away from their economic responsibility – i.e. liability. Again this can be identified to be an emotional response to the lack of reliable and transparent documentation of business practice. This made a case for EU commissary Öttinger publicly demanding an insurance duty for European nuclear power plants, as insurances already cover a large part of liability issues. Another issue would be the roles of liability and

To summarise, the communication to achieve the general public's acceptance on funding a project, needs to be

- transparent and intelligible, to enable people to assess the sincerity of the participants,
- and enabling participation, for the same reason.

Also, the content of the communication needs to make people understand

- the relative and absolute numbers of the funding,
- the origin of the funding,
- the merit of the technological project to the society.

The economic justification towards the public is a mainly rational and content based communication. However, it has to be observed that it must be intelligible to the general public and especially the merits have to be fleshed out with examples and scenarios underlining the positive character of the project.

Finally there is the question liability which can be answered by providing information on

- the cost of risks, their mitigation and respective insurances,
- the participation of public and experts in external costs.

It can be stated that this is the most important economic aspect involved in public solidarity and acceptance processes as it is the emergence of a fair and respectful business practice.

5.3. Facing special public

The special public in this case encompasses scientific public, stakeholders and shareholders and is related to the funding of the project. The respective roles are drafted in Figure 21. The scientific public is an important actor independent of the way of funding. Its opinion and estimation is called by both public funders and private shareholders or the enterprises demanding the experts to realise a given project as a service.

These recommendations can affect the funders' willingness to support or to continue supporting the experts. Therefore, a fair play relation to the scientific community (i.e. external experts) needs to be established beforehand. The individuals and groups of the scientific public should not perceive the experts as rivals – which may lead to a wrong and bad review out of political reasons – but rather as worthy competitors and potential partners sharing the same cause – which

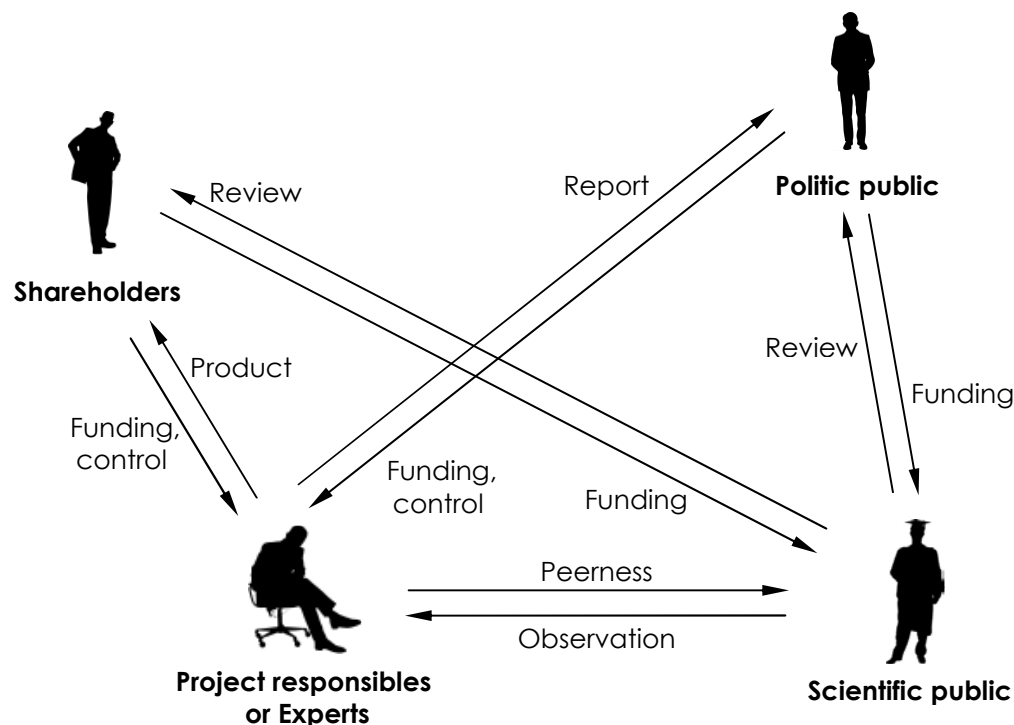


Figure 21 – Experts economic dependencies to special public actors.

could lead to an honest review serving as a constructive contribution and valuable inspiration. This calls for direct communication and truthful argumentation. It also calls for a work in observing other institution with similar interests, identifying their special capacities, their special topics and to conceive synergisms. Scientific work ethic is taken for granted.

Stakeholders, here political functionaries/political public deciding about the distribution of the public funding need to be informed diligently about the progress of the funded work. The quality needs to be disclosed. It is obvious that a complete transparency needs to be maintained towards the stakeholders. It is assumed that even in case of difficulties leading to a considerable shift in the project the stakeholder may react in an understanding way if the reason for the shift is intelligibly explained. This facet of an acceptance among the political public would ensure the project continuation despite unforeseen major difficulties. It can be observed in German Bundestag's dispute concerning ITER funding how a lack of insight concerning difficulties can erode political support to projects. A similar consideration can be made if the stakeholders are of an enterprise handing a project to a group of experts to realise it as a service or if the project is (co-) funded by shareholders.

It can be concentrated that

- that the scientific public makes a special actor which does affect the acceptance and allowance of funding in an indirect way through recommendations and reviews,
- that it is beneficial to treat the scientific public in a peer and fair play manner to avoid malevolently erroneous reports,
- and that stakeholders (both political and private) as a public need to be informed transparently and intelligibly about the progress of the project and obstacles encountered,
- acting responsibly towards special public is at least as important as to act openly towards the general public.

6. Dissemination Plan for DiPoP

6.1. Overview

The purpose of the dissemination plan for the project on Disruptive Technologies for Space Power and Propulsion is to share the findings with both general and special public and to obtain the acceptance for a continued research relying on public solidarity rather than on marketing artifices. As the special public of responsible stakeholders and politicians are already provided all the reports i.e. the most detailed information available, a focus is set on the scientific public among the latter. The journalistic public is considered to be an integral part of the general public which is addressed rather in a programmatic manner preparing further and more concrete projects.

6.2. Communicating with the Scientific Public

The communication with other scientists serves to share the findings and experienced with peer scientists. The recipients are thus students of the natural sciences and engineering and of all rank from Bachelor over Master to Ph.D. curricula, University scientists and Professors, junior and senior researchers at independent institutions and in industries etc. – i.e. people with both scientific training and interest. It is notable that two of the main aspects identified in prior chapters, SIOT and PUST are not truly applicable: The social solidarity among scientists is assumed to be relatively uncritical and conflicts merely driven by competition rather than by alienation. There is no case for PUST as the training of these recipients is nominally the best for the involved science.

Thus, it is possible for the individuals of the DiPoP consortium as a sender (see chapter 3.2 for the terminology of Laswell's formulation of communication) to rather focus on sharing the findings of the research conducted for DiPoP as a rational content using the usual channels: Publications in Scientific Journals, letters, presentations and talks at conferences on the topics involved, it could be also conceivable to prepare a summarising reference document. All of this is rather straight forward as it is a scientist's typical daily business.

The primary effect which can and should be expected is critical feedback. As all of the delivered work is just a piece of the greater whole and as it covers only certain aspects which were found and as there is obviously far more to be known, other scientists and responsible will comment, approve or criticise the findings. Channels to obtain this feedback is usually the review provided by journal editors, questions after conference talks, discussions, direct personal approaches as mailings or phone calls, lunch breaks etc. All of this will allow both estimating the value of the current findings and improving them, and it will allow obtaining new ideas and inspirations for further work. It is in particular beneficial to get acquainted to potential future partners in such projects as often it is more important to be seen with one's work rather than to seek others working on similar projects albeit not yet publishing. All together, this communication can provide for the seeding of any continued project.

In the same way the scientific communication is beaconing potential partners, it also makes visible to potential competitors. There is a delicacy. It is obvious that a dialogue among competitors is valuable as long as it does not lead to bad business practice such as collusion. However, there is also a crucial problem intrinsic to scientific competition: The product is generally knowledge and expertise and a scientific consortium is paid for producing and selling that. Most of the knowledge has been painstakingly acquired through sleepless nights and after days of difficult work. So there is apparently a value. Sharing however this product with competitors – already by the recommended means of transparency – therefore risks inflation of this intellectual labour. The responsible should hence take care that the transparency does not disclose details which are not protected intellectual property and watch the observation of good scientific rules such as the due referring by the competitor. Above that, they should also insist that the competitors apply a mutual transparency and ethics. Also note that with respect to this delicacy, all scientific dissemination has to be discussed among the consortium partners and especially the prime.

6.3. Communicating with the General Public

In contrast to the communication with the scientific public which can focus on scientific details, the communication with the general public requires a dedicated work following both the SIOT and the PUST approach. Again, the senders will be the individuals of the DiPoP consortium. The recipients in this case will consist of people forming the general public and will consequently be far more heterogeneous in both training and social setup. A majority will have no training granting a sufficiently high understanding of science and not even any pronounced social contact to scientists. Others will have perceptions according to which the scientists and engineers appear as an aloof group of technology aficionados or – even worse – a malevolent elite. The respective communication will thus have to rely on three pillars, SIOT, PUST, and project details.

The first pillar is the social permeation in order to achieve a good social implementation as described in chapter 3.1 above, where also recommendations on the modes of interaction are given. In recent years, the available channels to apply these have improved in both quality and number. Nowadays, in addition to public talks, lectures, and days of the open door offering an interested public in following receptions and social events an occasion to socialise with the responsible and to obtain an inside in their jobs, lives, and “*normalness*”, there are new media, namely the internet and in particular so called *social media* offering new options.

While communication via the internet may at first sight not appear suitable to communicate emotions which have above been identified to form solidarity and acceptance due to the internet being rather impersonal and bound to text and imagery, the social media can serve the social implementation as they lower the communication threshold among peer and rather transparent individuals by the distance of the web and ease participation as they offer easy to understand services and interfaces. In the example of Facebook which is currently the social medium with the highest impact and largest reach having one billion of nominal adherents, individuals can interact sending each other private or public mails and bulletins using the platform’s messaging service, make suggestions, approve propositions and so on. It is currently a property of the communication in these channels to rely on brief and catchy messages. Note however, that the messages and bulletins can also contain embedded material such as video or audio clips, hyperlinks to external material or other web sites other members are able to give a direct feedback to these asking questions, discussing the content or the proposition or briefly approving

it. In brief, this channel is low in details and meaningfulness of the messages, but rich in participation and transparency, handing out references to material rich in information it can disseminate a lot.

More interesting than that is however the *social reach* of this medium. Already known to Georg Simmel, an individual in modern society adheres to several distinct groups at once [R 16]. The individual can be – for example – a man, an engineer, a member of the DiPoP consortium, a fan of Stade Toulousain or VfB Stuttgart, a piano player, a cyclist, etc. which can be described as a social setup. This is individually distinct: Other cyclists may not necessarily be engineers, fans of these sport clubs etc. This individualisation may have erstwhile caused a certain disintegration; for example not all the cyclists solidarise with engineers. The new social media may allow to bridge this distance. Obviously the engineer described above may have friends among the individuals forming the respective groups and not all of these friends sport a perfect copy of this individual's social setup as described, but they have other friends according to their setup. The benefit of the social media consists then in reaching those, even if they have no personal social proximity to engineers. In the example of Facebook, the engineer may share a bulletin stating that he was happy to have learnt about a certain propulsion system. Then one of his cycling friends who is in the same time working as a tour guide may like, i.e. approve or even recommend this bulletin and thus share it with other tour guides who would otherwise never realise about any DiPoP activity. This is sketched in Figure 22. But above that, these third ones may realise that there were actually “real” individuals involved into space flight activities, with “real” emotions and a “real” person's ethics and responsibility, they can more easily identify with this engineer and develop feelings of support and solidarity.

Also the content of the bulletin can reduce the alienation of experts. In the example above, the bulletin message has two sides. On one side, there is the rational information about the new propulsion system which can also contain a hyperlink to an external source offering some explanation, for example to an article. On the other side, there is an emotion – being happy – which is seen as a part of being normal and sociable by people, making the engineer looking less alienated. Also the fact of posting this information in such a public channel with participation is communicating proximity to and solidarity with the general public. It can be assumed that this

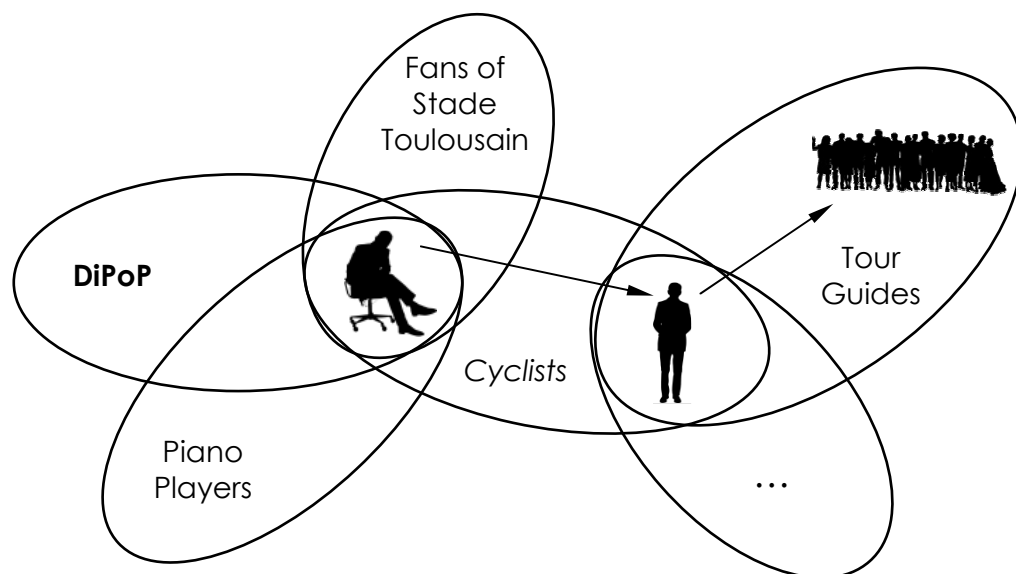


Figure 22 – Principle of experts' social reach in social media

can incite reciprocation and thus improve the social implementation. The effect can further be increased if also communicating messages on topics not necessarily related to the project. Sharing one's thoughts and opinions about daily life and or culture, ethics and pass-times may also help to reduce the risk of growing into a social risk. In addition to that the feedback which will eventually appear in this medium can help to estimate the state of one's social relation.

The second pillar is the communication with respect to the Public Understanding of Science and Technology which can be qualified as a more educative activity. Consequently, the classic means should be enacted, i.e. public talks and lectures, podium discussions and participation in the mass media, all as recommended in the Bodmer report [R 5]. Nowadays, there are even further options, again offered by the internet.

One of the most frequently called services in the internet is the Wikipedia, which is an international hypertext encyclopaedic available in all European languages. Wikipedia is an educational channel of communication similar to a normal print encyclopaedic enabling to look up the knowledge about a certain topic, but also allowing browsing related topics or browsing from scratch as a pass-time. An interesting feature of the hypertext articles in Wikipedia is the Matryoshka-like architecture which assures that the articles are still concise enough to be both enjoyable and readable. Not all the details are fleshed out in the article itself. Instead hyperlinks to other articles on these details allow the readers of Wikipedia to select which detail will be investigated in depth at which moment making it a versatile and flexible means to raise the PUTS.

Above that authoring in Wikipedia is accessible to everybody. While this may appear as a risk to the quality of the articles in Wikipedia at first, the experience of the last decade showed, that the peer review and discussions system as well as the policy to enforce references for statements managed to grant a rather good quality. Thus, experts may consider committing to contribute to Wikipedia articles as a part of the technical and PUTS dissemination. One of this document's authors learned during a visit to the Grande École Sciences Po in Nancy in 2007 that their students were required to write Wikipedia articles about topics in social sciences as a part of their homework in order to educate the public on those. It is thinkable to implement a similar approach at the public partners of DiPoP who are already engaged in education and receive students and interns on a regular basis.

The messages communicated in these channels more apt for PUTS than for SIOT can nonetheless be hyperlinked into the SIOT apt social media. This is true for Wikipedia articles, as conceivable in the example messaged drafted above, as well as for video clips recorded during public talks or lectures.

Other than that, there is a third pillar, which is the transparency of the project itself, encompassing the project setup, the resources, the reports, the technical database and so forth. These data can be made available through the project's principal web-page which should be designed to serve as a gateway. For one it should give hyperlinks to the data base and the hard facts, for another, it should link to the PUTS activities namely the videos of talks or the related articles in Wikipedia. Finally, there can be links to group-sites in social media and links to e-Mails to the participants. Downloadable content should be obtainable from this gateway.

To conclude, the dissemination is different for scientific and general public. The first will rely on the hard facts and the results of the project, the other on social permeation and activities aiming at an enhanced public understanding of science. The reason to do so is to enhance the solidarity towards the project's responsible and thus the acceptance of the project. Consequently, suitable means will have to be implemented:

Scientific dissemination of DiPoP:

- Publications in journals, letters,
- Presence at conferences, talks preferably video recorded,
- Discussions with other experts, preferably video recorded.

Public dissemination of DiPoP:

- *Means aiming at an improvement of the social implementation:*
 - Days of open doors, public talks and lectures, science fairs, public receptions
 - Participation in social media, individually, group page
- *Means aiming at an enhancement of the public understanding:*
 - Public talks and lectures, public courses, preferably video recorded,
 - Participation in Wikipedia
- *Means aiming at transparency:*
 - Sharing of project details through a gateway web site (already rudimentary implemented)

7. Conclusion: Recommendations and Dissemination Plan

The present document presents the final results of a study on public acceptance. A view from a top level has been taken considering general issues in the public acceptance of technologically disruptive or advanced projects. Observations of a current case example presented in section 2.3 have been interpreted and core issues identified. From this, it was concluded that:

- **Achieving public acceptance for realizing and using disruptive technologies is an interdisciplinary project demanding long term effort.**

It is interdisciplinary since there are many conflicts, problems, questions, issues to be addressed, each having its own particular nature. For example, there will always be concerns about the safety of a technology, or its ecological effect. These call engineering approaches to deliver a solid base of facts. The roles of responsibility need to be known and liability has to be defined.

However, there will always be emotional issues that cannot be addressed by facts only. Understanding this, it was concluded that any approach aiming at enhancing the Public Understanding of the involved science and technology – as vital as it is – has to be accompanied with an equally dedicated Social Implementation in order to incite a good level of solidarity for the responsible and therefore passive public support of the project. Achieving public acceptance will therefore also demand certain responses from the social sciences. Communication is also a vital aspect and in this document, it has been developed at many instances, that transparency is the best way to mitigate concerns of the public.

From this insight, strategies and recommendations have been derived:

- Reflection, awareness and adaption. Experts should:
 - Consider their social setup, behaviour and attitude towards project and public,
 - Consider their language skills and levels,
 - Follow the development of communication and its instruments,
 - Consider values and ethics and commit to technology assessment,
 - Apply measures according to their finding.
- Transparency and intelligibility. Experts are required to:
 - Communicate the fact base of the project in a language understood by the public,
 - Disclose the funding background,
 - Enable the public to follow their reasoning through preparing the public,
 - Commit themselves to education and present at respective institutions,
 - Dare to disclose their personal motivation to the public.
- Participation. Experts should:
 - Enable the public to ask questions about the project and respond these questions
 - And further seek the public debate.
- Education and Public Understanding of Science and Technology. The public should be scientifically capacitated to participate in the debate through:
 - Basic education keeping the level of nowadays scientific development.
 - Continued education keeping graduated individuals to the level.
 - *Note, that the Bodmer-Report [R 5] contains detailed recommendations.*
- Particular public. Experts should address particular public in a reasonable manner.

Achieving public acceptance is a long term effort because the available means to communicate to the public will take their time. It will also take its time for the public to have dealt with the communication and to form an opinion. Also there will be dynamics and the current public acceptance may change into refusal or vice versa. Finally, there are means that take intrinsically some time to apply, like public education aiming at enhancing the communication between experts and public by getting the latter to level.

Finally, an according dissemination strategy was developed. There are two main branches, one for the scientific and one for the general public. The first will rely on the hard facts and the results of the project, the other on social permeation and activities aiming at an enhanced public understanding of science. The reason to do so is to enhance the solidarity towards the project's responsible and thus the acceptance of the project and its follow-ups. Consequently, suitable means will have to be implemented:

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- *Means aiming at an improvement of the social implementation:*
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 - Participation in social media, individually, group page
- *Means aiming at an enhancement of the public understanding:*
 - Public talks and lectures, public courses, preferably video recorded,
 - Participation in Wikipedia
- *Means aiming at transparency:*
 - Sharing of project details through a gateway web site (already rudimentary implemented)

Since some of these means especially the dissemination of findings and facts through Wikipedia may take some time as well as other PUST activities, the DiPoP consortium should not fully disband after the completion of the project but maintain a board to observe these duties and check back with the other participants on a regular basis. In addition to that, feedback can be obtained repeatedly over time through polls, interviews and lost letter experiments which is encouraged in order to obtain an empirical database on the opinion of science similar to [R 29].