

Evaluation of ‘learning’ as a main thrust in the transferor-transferee relationships in small satellite technology transfer collaborative projects between developed and developing countries: the case of Algeria.

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Abstract

This article focuses on the transferor-transferee relationship in the context of technology transfer collaborative projects between developed and developing countries. The case of the Algerian satellite industry which utilised three small satellite collaborative projects with foreign companies over 20 years in order to acquire technology from abroad has been used as an empirical study. The study evaluates transferor-transferee relationships when small satellite collaborative projects are used as a technology transfer mechanism. It assesses whether technology transfer effectiveness or ‘learning’ is mutually understood by the two key transferor and transferee actors. It identifies a potential schism when transferor motives are often economic (business-oriented) whilst transferee motives are non-economic, aiming to learn and develop local capabilities for national developmental objectives. The study reveals that this initial non-alignment of objectives led to the adoption of a transfer mechanism where learning is not the main thrust. The principal finding extrapolated from this research is that this inadequacy is rooted in the fact that Algerians had not clearly dissociated the objective of ‘satellite technological learning’ from that of ‘satellite applications’. Recommendations for future research include the need to clearly prioritise the objective of ‘technological learning’ to avoid confusion as to the transfer mechanisms to adopt.

Keywords: Knowledge management, technology transfer, small satellite collaborative projects, transferor-transferee relationships, developing countries

1- Introduction

Following the launch of the first Earth-orbiting satellites in the late 1950s, the potential for space technology along with its satellite technology applications to make essential contributions to economic and social development were quickly recognised by the international community. Space activities expanded quickly in the following decades and demonstrated their usefulness in everyday life (Detsis and Detsis 2013; Williamson et al. 2001; UNOOSA-a 2015; UNOOSA-b 2015; Waswa and Juma 2012). Dupas (2010, 2005) explains that space development occurred in three waves. The first was mainly led by development in science exploration and manned space flight in the 1960s. The second wave in the 1970s was led by the development of military space programmes. The third wave was led by the 1990’s development in information space programmes, and is still ongoing. This wave has had a

considerable effect on space development. It is driven by the revolution in information and communication technologies and the tendency towards a globalised space sector, characterised by international collaboration and the growing role of commercial activities (Dupas, 2010). It is also driven by technological advances in miniaturisation and performance of off-the-shelf components contributing to building smaller and cheaper spacecraft. This trend brought a concomitant reduction in domestic space budgets and gave rise to a new ‘small’ satellite business model. Consequently, there is growing interest in space on the part of budget-limited developing countries. The trend has opened up the exclusive ranks of ‘spacefaring’ industries to new entrant states, engaged in building satellite technology capability through acquisition of small satellites via technology transfer programmes using the mechanism of collaborative projects (Wood and Weigel 2014; Leloglu and Kocaoglan 2008).

However, despite the popularity of small satellite collaborative projects, there is a lack of objectivity as to their effectiveness in transferring satellite technology to developing countries. A cautious stance should be adopted when using collaborative projects as a technology transfer mechanism, and, accordingly, the topic requires a deep evaluation of this mechanism. The satellite industry is a knowledge-intensive industry (OECD, 2001) where developing countries aim to build, local technological capabilities from the technologies transferred through collaborative projects. Yet, by contrast, developed countries, as suppliers of technology, recognise that in a globalising world, their knowledge base provides the major comparative advantage in the highly competitive technology market. However, maintaining it requires protectionism. Reconciling these two competing goals is challenging. This article identifies factors underpinning the transferor-transferee relationship. It evaluates ‘learning’ in this relationship within the context of collaborative projects used by Algeria.

The article then reviews international technology transfer mechanisms and highlights the need for a focused approach defined according to the actors (i.e. transferor and transferee) and the technology to transfer. The principal elements underpinning the transferor-transferee relationship are examined. Following this discussion, the mechanisms used in the transfer of small satellite technology are presented, and the mechanism of collaborative projects is thoroughly examined from a project management perspective. To close, the findings of the evaluation of the transferor-transferee relationship in the case of Algeria are analysed. A set of conclusions and recommendations are offered to inform future research.

2- Technology transfer mechanisms from developed to developing countries

The objective of technology transfer is to support local technological capability-building, described in the literature as the local diffusion of technology (Kim 1997; Chen 1996; Rubenstein 1976). In order to achieve successful technology transfer in developing countries, a combination of mechanisms is used (e.g. licensing, sub-contracting, equipment and material supply, and consultancy). Technology transfer can be regarded as a three-element process comprised of transferor, transferee and linkages (Sharif 1986).

The UN Centre on Transnational Corporations (1987) has identified another technology transfer typology, comprising commercial (FDI - foreign direct investment, joint ventures, licensing) and non-commercial (publications, foreign students, training). The use of FDI as a technology transfer mechanism prevails in developing countries (Cohen 2004). Newly

industrialised countries (NIC) have made use of unconventional mechanisms in acquiring advanced technology (e.g. electronics and the computer industry). Countries like Japan, South Korea and Brazil used reverse engineering and product imitation to acquire new technology (Kahen 1999; Sacerdoti 1986; Erber 1985). Taiwan, China and South Korea adopted the mechanism known as 'reverse brain drain' by attracting experienced expatriates from abroad and putting them in appropriate institutions or industries (Sahay 2014).

It is important to mention that whatever the mechanism used, technology transfer is greatly affected by industry-specific factors (e.g. products, facilities), region-specific factors (e.g. cultural considerations), country-specific factors (e.g. political and economic systems), and organisation-specific factors (e.g. existing knowledge, management) (Malerba and Nelson 2011).

The complexity that arises from the association of those factors with the available mechanisms makes clear that there is no one-size-fits-all solution for developing countries. Each country has to seek its own transfer mechanism (or combination of mechanisms) alloyed with peculiarities of the technology to be transferred (Cohen 2004).

3- Transferor-transferee relationship

Successful transfer is highly dependent on the strength of the linkages between the transferor and transferee (Saji et al. 2005; Sharif 1986). Indeed, building sound linkages is underpinned by the depth of the mutual understanding of transferor and transferee interests, and the coordination between them. Transferor motives are often economic (business-oriented). Transferee motives, on the other hand, might be economic or non-economic, but often aim at building local capabilities for national developmental objectives. Mutual understanding may explain, for instance, why multinational corporation strategies are often in line with local economic firm objectives, but virtually always different from national developmental objectives (Cohen 2004).

Mutual understanding is also a matter of balanced negotiation and bargaining power (Boddewyn 2016). In general, developing countries have low bargaining power compared to developed countries because of prior knowledge limitations, immature international experience, and imbalanced market structures (e.g. supplier markets) (Contractor and Woodley 2015).

In order to establish sound transferor-transferee linkages, Lee et al. (1988) point out the need for the transferee to adapt technology transfer strategies in accordance with the technological development stage reached. Adaptation occurs by choosing suitable transfer mechanisms. These mechanisms depend on the transferee's technological capabilities and the technology life cycle; they, in turn, depend on the transferor's willingness to adhere to them, considering criteria such as technological novelty, the strategic importance of transferor activities and further considerations like intellectual property protection.

Abernathy and Utterback (1978) and Utterback (1994) put forward a technology trajectory model illustrating the technology life cycle in developed countries. It explains that technological change rate or product innovation occurs over three main phases: (i) The fluid phase or the emergence of the innovation, where the radical product innovation rate is higher

than the incremental innovation rate; (ii) The transitional phase where product varieties converge towards a dominant design, and there is a need for a product consolidation; and (iii) the mature phase, where the product is mature and the innovation occurs at a small incremental rate. Kim (1999) connected technological trajectories in developed and developing countries. The transferee which successfully acquires mature technology and assimilates it may shift to acquisition and then assimilation of more sophisticated (high) technology. The transfer process continues even when the transferee reaches the level of generating its own technology. Kim (1999) further argues that linkages are possible at several stages. Technology can then be transferred at the mature, transitional or fluid stage.

Transfer success predominantly depends on the absorptive capacity of the transferee (or learners) (Zahra and George 2002; Zahra et al. 2009). Cohen and Levinthal (1990) argue that the absorptive capacity of learners, at the organisational level, hinges largely on the level of prior related knowledge (existing knowledge base) and the intensity of learner effort. The prior knowledge base grows through continuous learning occurring under normal circumstances (Cohen and Levinthal 1990). Intensity of effort refers to the level of effort invested by the organisation to assimilate and utilise new knowledge. It relates more to discontinuous learning that occurs under abnormal circumstances (Kim 1999). Kim (1999) argues that the intensity of organisational effort has a preponderant influence as compared to the influence of prior knowledge, particularly on long-term learning. This intensity is translated through actions of both continuous and discontinuous learning. For instance, Chen and Li-Hua (2011) argue that when technology is at the embryonic stage in developed countries, firms in developing countries can seize the opportunity for leapfrogging (discontinuous change) through in-house R&D. Success depends on the availability of funds, talent and government support. It also depends on a self-innovation culture and abilities requiring considerable time to build, without which leapfrogging opportunities are very hard to seize. As a result, some NICs have used other mechanisms, such as exercising a measure of control over host firms in developed countries (e.g. holding shares, market access) for the purpose of, inter-alia, expediting self-innovation abilities (Chen and Li-Hua 2011). Therefore, in addition to the knowledge-accumulation perspective, the knowledge non-accumulation perspective is relevant for understanding the transfer of high technology systems, such as satellites. This is particularly true in today's ever-changing environment, where knowledge does not necessarily accumulate and is not necessarily path-dependent (Garud 1997).

Cultural differences is another potential impediment to sound linkages and mutual understanding between the transferor and transferee (Stahl and Tung 2015). Culture is a collective phenomenon (Hofstede 2011). This concept is rarely monolithic and can only be characterised by heterogeneity (Bhagat et al. 2002). Its nature can differ according to the level of aggregation (e.g. nations, organisations, or other collectives) and the particular cultural dimension. In a technology transfer context, these factors are interwoven with others involved in the transfer process, such as knowledge types, absorptive capacity, language, geographical proximity and international experience (Kedia et al. 1988; Bhagat et al. 2002). In view of this complexity, the present study is limited to examining management practices at an organisational level that shape the learning culture that facilitates technology transfer. Some of the most influential practices are quality practice, training, management commitment, sharing and understanding (inter-personal social interaction), and team-based work (Nguyen and Aoyama 2014). Moreover, organisations which delegate responsibilities, tolerate creative

mistakes and provide slack time to work on new ideas, foster a learning culture (Cummings and Teng 2003).

4- Small satellite technology transfer to developing countries

The dynamics that have emerged over the last twenty-five years in building small satellites have lowered barriers to entry for newly industrialised and developing countries (e.g. South Korea, Malaysia, Turkey, Algeria, Nigeria, and Chile) (Argoun 2012; Lee and Chung 2011). These countries have engaged in a process aimed at moving from a passive status (i.e. user) to a more active status (i.e. operator and then manufacturer). This process corresponds to moving up the space/satellite supply chain levels (OECD, 2014), from generating services at downstream activities, such as users/generators of satellite services or products (e.g. use of satellite images in cartography, agriculture, urban planning and defence & security) to producing space assets (e.g. satellites or ground segments) and finally to satellite manufacture. At each of these stages, a technology transfer is carried out and its success predominantly depends on the absorptive capacity of the transferee. The latter has to manage a combination of industry-specific factors (e.g. products and facilities), region-specific factors (e.g. cultural considerations), country-specific factors (e.g. political and economic systems) and organisation-specific factors (e.g. existing knowledge and management) (Malerba and Nelson 2011).

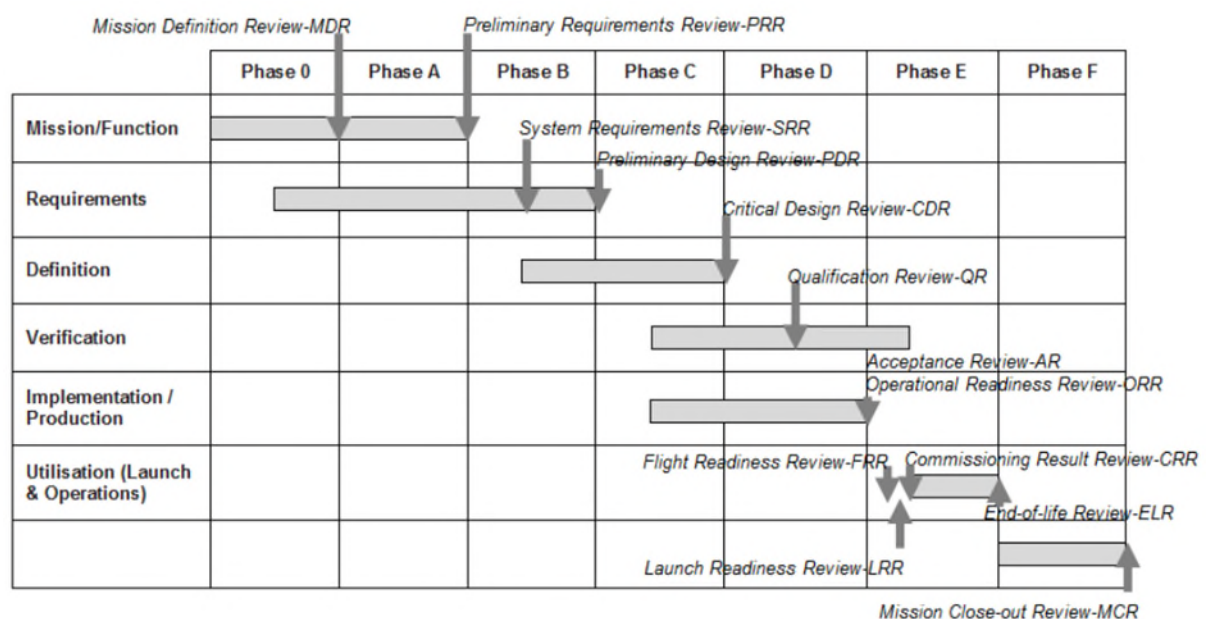
Wood and Weigel (2014) identify four models that have been used by these countries for implementing early satellite projects: (i) Turnkey projects that are used when the customer is only in charge of operating the satellite after its launch, and managing its applications. This model is generally used to procure high capability (i.e. performance and advanced technology) satellites; (ii) Local university projects are the model for local organisations favouring training benefits over capabilities. In this model, much of the development effort is spearheaded by a local university (e.g. design, training, manufacturing and operation); (iii) Overseas education with local development. It refers to the situation where local organisations seek to use knowledge acquired abroad for developing satellites locally. This model is generally used when the local organisation wants to leverage foreign knowledge to facilitate and speed up local development; and (iv) collaborative satellite development. This refers to projects where a combination of academic and hands-on technical training is provided to the customer's engineers and scientists. It often involves countries seeking to take their first steps in satellite technology but constrained by an affordable budget. The customer's engineers spend time and work together as a team with supplier engineers to build and launch the satellite. Then, the customer's engineers solely operate the satellite. The mentoring provided by the supplier's engineers enables the customer's engineers to commence working on complex systems that will allow honing of the diverse sets of skills required for satellite development. In this model, the supplier leads the process of satellite design and manufacture. This way of manufacturing small satellites was largely popularised by a University of Surrey-owned spin-off company, Surrey Satellite Technology Limited (SSTL) (Petroni and Santini 2012). Small satellite collaborative projects are perceived to be the most common mechanism of international satellite technology transfer directed towards small developing countries (Wood and Weigel 2014; Wood and Weigel 2013).

5- Small satellite collaborative projects

Small satellite collaborative projects are tailored according to the internal capabilities of the host organisation, its absorptive capacity and its ambition, balanced by the supplier's willingness to transfer technology (Wood and Weigel 2014). Three training types are generally provided during such projects: theoretical, practical and on-the-job (Wood and Weigel 2014). The first refers to learning from courses or documentation. It is usually assessed through formal mentoring system and formal accountability (e.g. academic evaluation, tests, dissertations and presentations). The results of theoretical training are relatively easy to convey to the host organisation for control purposes. The second (practical training) refers to the application of skills learnt through practical work and on tasks that are not necessarily related to the manufactured satellite. This training is recommended when trainee skills are below those required for satellite manufacture. It is usually assessed through an informal mentoring system and 'informal' accountability. It is relatively difficult to control by the host organisation. The third (on-the-job training) refers to practical tasks performed by the trainee, under the supervision of a mentor, aimed at building the satellite. These activities are suitable when trainee skills match the skills required for satellite manufacture. The trainee's contribution is assessed like any other team member's contribution. On-the-job activity is relatively difficult to control by the host organisation.

Small satellite projects are generally conducted through a number of phases (ECSS 2009). Each phase has a prevailing activity, and the transition from one phase to another is marked by a review. The latter has to attest to the successful completion of the previous phase and the readiness to start the next phase (as part of risk management). As illustrated in Figure 1, the satellite project life cycle is typically composed of the following phases: phase 0: mission analysis/needs identification; phase A: feasibility; phase B: preliminary definition; phase C: detailed definition; phase D: manufacturing, assembly and testing; phase E: launch and operation of the system; and phase F: disposal (customer disposal).

Figure 1: Typical project phases and reviews

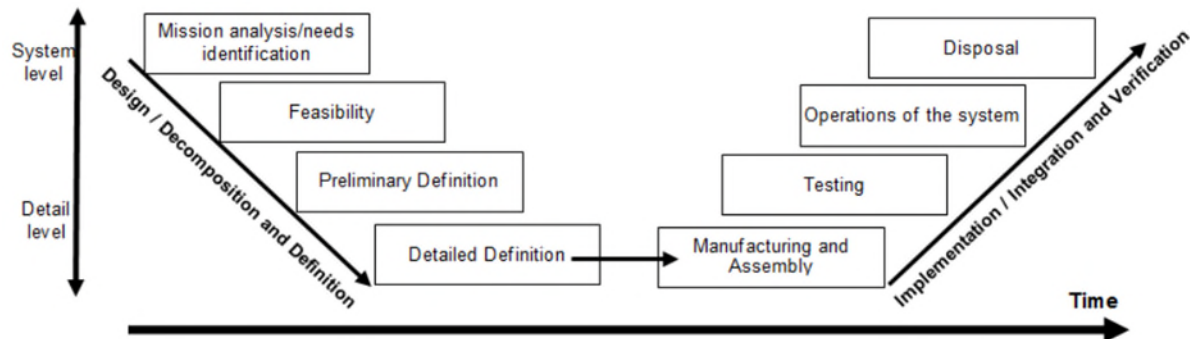


Source: Adapted from ECSS (2009:19)

Forsberg and Mooz (1999) illustrate the overall evolution of space system design and implementation (see Figure 2) as a V-shaped process. The design is a top-down process, whereas the implementation is a bottom-up process (Forsberg and Mooz 1999). During the design (i.e. top-down) process, a large multi-disciplinary team of engineers creates satellite models using specialised tools and software. The process is based on intense dialogue between the prime constructor and both the customer and the suppliers – to refine needs and technical specifications. In general, small satellites are seen as one-off products. However, they are often designed quickly (in approximately 1 to 3 years), as they rely on previous designs and components.

During the implementation (i.e. bottom-up) process, a separate team of technicians implements the design produced by the engineering team. As the satellite will be employed in a harsh extra-terrestrial environment, it has to be rigorously tested (including its components) over months throughout the implementation phases. These tests are crucial, and some of them require specific and often expensive equipment and facilities (e.g. chambers for testing satellite behaviour under extreme space-like temperatures and pressures and vibration equipment for testing the satellite structure). In general, for small satellite projects, approximately 50 to 100 people (involved in engineering, technical and managerial tasks) are required to complete a project, as opposed to hundreds of people for large satellite projects.

Figure 2: The V-Process of satellite design and implementation



Source: Authors' combination of models presented in Forsberg and Mooz (1999:924), Aguirre (2013:12) and ECSS (2009:19)

Aguirre (2013) stresses that the upper part of the 'Vee' relates more to the aggregated aspects of the system (i.e. system level in Figure 2) involving few engineers, while the lower part refers more to disaggregated aspects (i.e. detail level in Figure 2) involving larger teams. According to ECSS (2009), the top-down process starts from the Preliminary Requirements Review (PRR) to the Preliminary Design Review (PDR). The bottom-up process starts from the Critical Design Review (CDR) to the Acceptance Review (AR). The time between the PDR and the CDR is used for equipment procurement and development. Any procured (e.g. off-the-shelf) or manufactured item should undergo its own development cycle, starting from the requirements definition onto integration at an upper level (e.g. unit, subsystem, system).

6- The case of Algeria

Algerian satellite development activities are located within one of the Algerian space agency's affiliates, namely the Centre for Satellite Development (CSD). The CSD has leveraged three small satellite collaborative projects (Alsat-1, Alsat-2 and Alsat-1B) with foreign companies in order to acquire technology from abroad. Alsat-1¹ and Alsat-1B² are two small satellites built in 2000 and 2014, respectively, in conjunction with SSTL-UK. Alsat-2 comprises a pair of identical satellites (Alsat-2A and B)³ built jointly with Airbus-France in 2005 and 2012. The Alsat-2 project is perceived as one system, because most project phases began in 2005 and involved both satellites. Alsat-2A was completed and launched in 2010, whereas the integration and test phase of Alsat-2B commenced in 2012, and its launch occurred in 2016.

This study is part of a broader empirical evaluation of small satellite technology transfer and capability-building in Algeria. Algeria's strategy takes a two-pronged approach: firstly, acquiring small satellite technology from abroad, and, secondly, diffusing the technology locally. The broader empirical evaluation revealed both the type and depth of knowledge acquired by Algeria in small satellite collaborative projects (Ayad et al. 2020), and the knowledge diffused locally (Ayad et al. 2019). A key component of this process are the relationships between the transferor and transferee in the collaborative projects. In particular, there is a need to understand whether transfer effectiveness or 'learning' is mutually understood by the two actors (i.e. transferor and transferee). Algerian engineers and scientists directly involved in the development of Alsat-1, Alsat-2, and Alsat-1B are logically those who have directly benefited from this learning.

6-a- Evaluation model

Transferor-transferee exchange occurs predominantly during the lifetime of a collaborative project when transferor and transferee teams work together. The type and depth of knowledge acquired by the transferee during collaborative projects are evaluated in Ayad et al. (2020), whereas the knowledge diffused locally is evaluated in Ayad et al. (2019). In the present study, the methodological approach adopted is to assess the objective of 'learning' during the project, through the joint management mechanism adopted by both the transferee and the transferor. The management mechanism is "fostered around project goals and paced by the project life cycle" (Ahern et al. 2014, p1371). The project cycle V model is then used to frame the evaluation of the mutual understanding of 'learning' from the perspective of both the transferor and transferee.

Traditionally, the project cycle captures three congruent aspects of the project, namely, the business, the budget, and technical aspects (Forsberg et al. 2005). However, it should not be used as a generic tool. It should be customised (or tailored) according to the project's strategic objectives and the tactical approaches adopted for achieving those objectives (Forsberg et al. 2005). As the strategic objective under evaluation in the present study is 'learning', the V model is tailored accordingly. The first step of tailoring is to select the appropriate period that is relevant for the 'learning' objective. The traditional phases of satellite projects are used for this purpose (Figure 3): mission analysis/needs identification, feasibility, preliminary definition, detailed definition, manufacturing (or procurement), assembly and testing, launch and

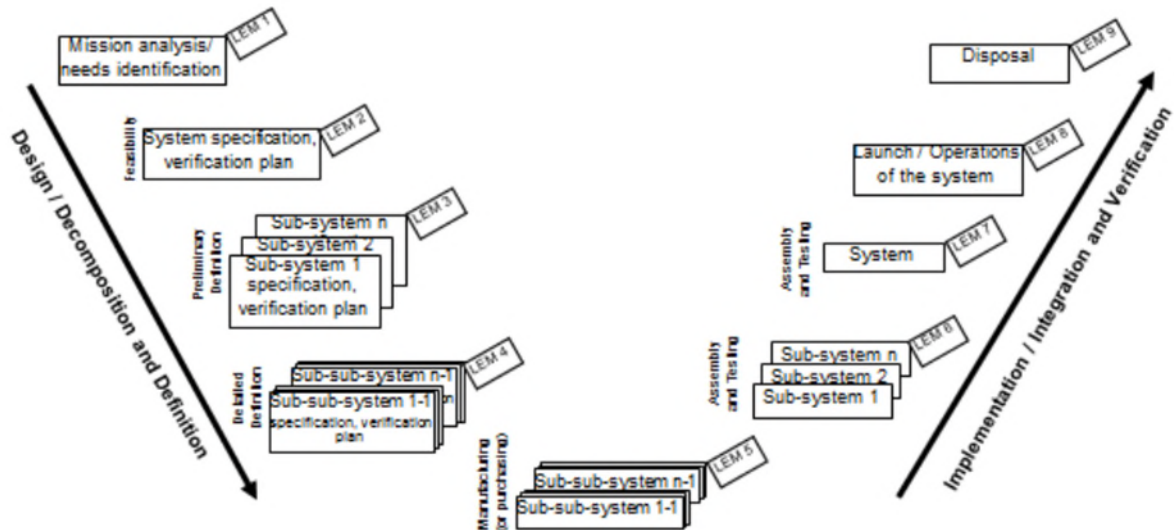
¹ Alsat-1 is classed as a micro-satellite (mass = 92 kg) (Petroni and Santini 2012).

² Alsat-1B is classed as a mini-satellite (mass = 110 kg) (Petroni and Santini 2012).

³ Alsat-2A and Alsat-2B are classed as mini-satellites (mass = 120 kg) (Petroni and Santini 2012).

operation of the system, and disposal (ECSS 2009). The second step in tailoring is to mark the decision gates (or milestones) and the associated phases that are relevant for ‘learning’ (i.e. LEM for Learning Evaluation Milestones as detailed in Figure 3). The third step is to identify project deliverables and associated metrics that evidence learning at the end of each phase. The final step is to identify tasks required to produce the deliverables.

Figure 3: Project cycle tailored according to 'learning' objectives



Source: Authors.

Learning Evaluation Milestones (LEM) are interim milestones wherein transfer of knowledge should be evaluated by the transferee. For instance, in LEM 1 (Figure 3), the emphasis is on evaluating learning to conduct a mission analysis, identify needs, and translate them into a technological system. In LEM 2 and LEM 3, the emphasis is on metrics measuring integrative knowledge (e.g. system engineering function, skills, software, equipment, facilities, documentation) and component knowledge (e.g. the subsystem involved, skills, software, equipment, facilities, documentation) required for designing the whole system (Ayad et al. 2020; Henderson and Clark 1990). At this level, local acquirer capabilities should be evaluated to yield an evaluation of local value. In LEM 3 and LEM 4, the emphasis is on designing subsystems. With regards to local value, actors involved are those at the lower level in the supply chain. The same rationale applies at each of the Learning Evaluation Milestones in both legs of the V model (Figure 3): design/decomposition and definition, as well as implementation/integration and verification.

6-b- Data collection

Data were collated as part of a broader empirical evaluation of Algerian small satellite technology transfer and capability-building. A mixed method design was adopted. A staged fieldwork was conducted in three campaigns, spread over a 13-month period from April 2016 to May 2017, to gather data using multiple methods (i.e. secondary data, structured, semi-structured, in-depth interviews and participant observation). Data were collected at three levels of analysis: individual and team level (i.e. micro level); organisational and inter-organisational level (i.e. meso level) and sectoral, national and international level (i.e. macro level). 40 mixed

(structured and semi-structured) interviews were conducted at micro and meso levels, with members of satellite project teams, and representatives of entities involved in satellite capability-building in Algeria and foreign satellite suppliers engaged in the projects. At the meso and macro levels, eight semi-structured and in-depth interviews were held with representatives from the CSD, the top management echelon of the Algerian Space Agency, and its local partners. The participation rate for this study was 73.84%. Questions were sent to the interviewees well before the interviews. At the initial stage, the questions were self-administered, and interviewer-administered later.

Participant observation was conducted by this paper's lead author, who has been employed at both technical and managerial levels in the Algerian space sector for the last 19 years. The combination of roles between 'participant-as-observer' (i.e. 'involved' in space activity, overt observation) and 'observer-as-participant' (i.e. 'uninvolved' in space activity, overt observation) (Guest et al. 2013, p.88; Bryman and Bell 2007, p.454) reflects the lead author's overlapping roles qualifying as 'interrupted involvement' (i.e. previous or sporadic engagement over time and revealed identity) (Easterby-Smith et al. 2012, p.144). Primary data generated from the participatory observation relate mainly to meetings held between the CSD and suppliers. Secondary data relate to a number of informal conversations conducted in the first author's presence. Experiential data relate to perceptions formed by the author during observation.

6-c- Findings and discussion:

Data collected revealed that transferor-transferee exchange occurred predominantly during the lifetime of the collaborative project. This is why the adopted approach was to examine the objective of 'learning' during the project. During fieldwork, the emphasis was on whether the strategic objective of 'learning' was explicitly recognised, first of all by the transferee (i.e. Algerians), and then by the transferor (i.e. foreign partners), throughout the project phases. This should be reflected in whether each phase had an explicit learning objective, whether the metrics for evaluating learning were known, whether deliverables that evidence learning were understood and tasks required for producing the deliverables explicitly defined. Table 1 summarises degrees of explicitness (i.e. explicit, moderately explicit, lowly explicit, non-explicit) revealed by participants in the collaborative projects.

The study confirms that Algerian engineers did not participate in the project design phase and instead mainly worked on technologies inherited from previous approved designs. Consequently, learning as part of the design/decomposition and definition phases (i.e. left leg of the V model in Figure 3) is overlooked. An exception has been made for the first phase (i.e. mission analysis/needs identification in Table 1) where learning is explicit or moderately explicit as an objective. However, satellites are complex product systems (CoPS) (Hodbay 1998). The emphasis of CoPS production "is on design, project management, systems engineering and systems integration" (Hodbay 1998:690). Non-prioritisation of learning about design is reflective of the Algerians' limited absorptive capacity and the lack of understanding (or prior knowledge) about the importance of design in such projects.

Learning in the final phase is explicit. This is reflective of the importance given by Algerians to building capabilities that enable local engineers to independently operate satellites. On the

other hand, learning aspects in the prior phases (i.e. manufacturing -or procurement-, assembly and testing, and launch and operations) are either non-explicit or not explicit enough (i.e. lowly or moderately explicit). For instance, during manufacturing, assembly and testing, work packages were used to guide the actions to be undertaken by Algerian engineers during the projects. These work packages, which are supposed to trace the road map for learning, were, according to participants in the collaborative projects: (i) sometimes not understood; or (ii) deemed very general and not detailed enough; or (iii) too narrowly oriented towards rather specialised aspects; or (iv) not properly balanced (i.e. fostering either theoretical or practical aspects); or (v) in disregard of the prior knowledge of learners and their absorptive capacity; or even (vi) dependent upon the transferor's willingness or availability

Table 1: Learning objective during collaborative projects

Project phases	Explicitness of learning objective	Explicitness of learning evaluation metrics	Explicitness of deliverables that evidence learning	Explicitness of tasks required for producing deliverables
Mission analysis/needs identification	Explicit	Moderately explicit	Moderately explicit	Moderately explicit
Feasibility	NC	NC	NC	NC
Preliminary Definition	NC	NC	NC	NC
Detailed Definition	NC	NC	NC	NC
Manufacturing (or procurement)	Lowly explicit	Non-explicit	Non-explicit	Non-explicit
Assembly and Testing	Lowly explicit	Moderately explicit	Moderately explicit	Moderately explicit
Launch and operations	Lowly explicit	Non-explicit	Non-explicit	Non-explicit
Disposal	Explicit	Explicit	Explicit	Explicit

NC (Not Considered): mentioned when learning is completely not considered

Source: Authors.

In addition, the fieldwork revealed that less attention was paid to learning as an objective at interim milestones. The disparity in the prior knowledge (absorptive capacity) of Algerian engineers made it difficult to thoroughly devise and evaluate a homogeneous and detailed learning programme. Consequently, at the interim milestones, learning strategy and tactics were rarely examined, and risks and opportunities related to learning were rarely assessed. Additionally, learning objectives and schedules were not often re-examined or adjusted.

Minutes of meetings relating to milestones in the Alsat-2 and Alsat-1B projects were reviewed and meetings of the Alsat-1B project were attended. It was noted that learning as an objective was insufficiently examined. The bulk of discussions or actions were centred around technical aspects and scheduling. A detailed project learning plan was insufficiently addressed. The

reason given is that it would be a difficult task given the wide range of uncertainties and changes faced. It is apt to highlight that the attitude towards a detailed learning plan runs contrary to the adage: 'The harder it is to plan, the more you need to'.

Evidence gathered, and represented by the shaded areas in Table 1 suggests that the Algerians assessed learning more through a summative perspective, with an emphasis on final and tangible outcomes and results. In other words, the learning processes within the project were addressed as a black box, where the emphasis was on outcomes. However, learning in such projects is often a long and laborious process, and rarely produces swift and tangible outputs (Lall, 1992; Davenport and Prusak, 1998). Therefore, Algeria's small satellite projects do not easily lend themselves to traditional evaluation based on the 'instrumental' use of outcomes. Such evaluation approaches lead to distorted perceptions of the transfer process, preventing deep understanding and the adoption of appropriate measures for enhancing transfer (Patton 2004; Patton 1996).

Even though learning should have been the Algeria's strategic objective, it is clear from the evidence that it was not the driving force behind the projects. It is likely that other aspects (i.e. technical, cost-related and scheduling) prevailed. These other aspects reflect the prevalence of the foreign partner's strategic objectives. Consequently, the initial non-alignment of objectives led to the adoption of management tools (i.e. the project cycle) that serve the interests of foreign companies rather than those of the Algerian Centre of Satellite Development (CSD). This often resulted in an uneasy, conflictual, relationship between the Algerians and their foreign partners. The prevalence of non-learning objectives goes a long way towards explaining the ambivalent perspective on Algeria's part towards learning performance. A sense of frustration and dissatisfaction was expressed, in particular by the Algerian managerial-level participants in this empirical study, over CSD's inability to overcome learning barriers after three attempts (i.e. Alsat-1, Alsat-2, and Alsat-1B). Some of the reasons are thought to be domestic, whereas others relate to the transferor's lack of willingness to fully transfer technology.

As the evidence suggests, CSD's management tools used during the collaborative projects do not prioritise transferee learning objectives. This prompts questions about the appropriateness of CSD's other management practices during the projects, and whether they foster a more active transferee role in the building of sound linkages between CSD and foreign companies. Mutual understanding between CSD and foreign companies is also a matter of cultural considerations and negotiating balance. This largely hinges on CSD's management practices that shape the learning culture and facilitates technology transfer, the prior knowledge of CSD, international experience and the market (whether it is a buyer's or a seller's market).

Analysis of the effects of transferee absorptive capacity on knowledge flow shows that CSD increased its prior technological knowledge over the projects' timeline. CSD's international experience increased after three collaborative projects. The differences in the ways of building satellites between SSTL and Airbus was highlighted in the fieldwork. A key point was that diversification of foreign partners brought diversity of international experience. Further highlighted was the importance of the human dimension in relation to SSTL (i.e. a small company) and the importance of formalism and procedures in relation to Airbus (i.e. a large company).

In addition, evidence from the fieldwork highlighted that the diversification of international experience offered broader perspectives and greater bargaining power in a market which is

dominated by a few suppliers. However, concerns about the future were expressed, as large companies such as Airbus perceive a threat in the emergence of smaller companies, such as SSTL. To address this threat, Airbus acquired SSTL in 2008 (Petroni and Santini 2012). The effect of this acquisition impacted on the Algerians. The fieldwork revealed the relative ease in which CSD was able to collaborate with SSTL during the Alsat-1 project when SSTL was a small independent company. This ease in collaboration was no longer present to the same extent during the Alsat-1B project, as SSTL had become part of Airbus. Collaboration was increasingly dominated by administrative procedures and contractual clauses. Moreover, concerns were expressed by Algerians about the consequences of this trend in terms of further limiting their bargaining power and rendering relationships with suppliers difficult.

Given the complexity of the cultural construct, the present evaluation only examined a subset of factors that influence mutual 'cultural' understanding in collaborative projects. For instance, in the projects conducted with SSTL-UK (i.e. Alsat-1 and Alsat-1B), English as the working language made communication difficult between the Algerian engineers and their counterparts from SSTL. Not to mention the relationship difficulties caused by the idiosyncrasies of personality type. Concerns were expressed about the selection process for the engineers and the need to improve it was stressed. In addition to appropriate language training, the need to introduce psycho-technical tests for team members was suggested by Algerians as not all of the members have the ability to work in a team and under the pressures exerted in such an innovative industry. In general, for a better understanding of the relationship between CSD and foreign companies, it was suggested by Algerians that the former should enhance management practices to overcome cultural barriers.

7- Conclusions and recommendations

Algeria leveraged collaborative projects to develop her own satellite capabilities. The study reveals that collaborative projects, as used by Algerians, turn out to be inappropriate for effective transfer of small satellite technology. Projects were led by foreign companies. Algerians did not have effective project control. Consequently, the central aspect in the management of satellite development was under-explored by Algerian teams. This was reflected through the way risk was managed. Because contractual responsibility lay primarily with the suppliers, the common practice of Algerians was to transfer risk to foreign companies. The study reveals that Algerians were involved, guided some decisions, provided inputs, but were not primarily responsible for the final product.

Satellites were built using technologies inherited from previous approved designs. The satellite design aspect was not covered by this transfer mechanism, and Algerians could not develop technical and managerial skills related to design. Yet the primary significance of the design phase is in acquiring long-lasting architectural knowledge and gaining creative independence (MacCormack et al. 2010; Baldwin 2010; Henderson and Clark 1990). Moreover, learning turns out not to have been the main thrust of the transfer mechanism. As the projects were led by foreign companies, aspects which are more relevant to foreign companies (i.e. technical, cost-related and scheduling) prevailed. In addition, the mechanism used did not allow proper monitoring and assessment of learning due to the management tools adopted. Difficulties increased as the bulk of the projects were conducted at supplier facilities (i.e. UK or France), far away from CSD management. This distance isolated the Algerian participants technologically from their local environment. Project emphasis was placed on these participants only. Projects did not involve other local actors in Algeria. Consequently, the

learning effort fostered during the projects ceased at the end of those projects. The mechanism used lacks connectivity with post-project learning.

The study reveals that Algeria faced difficulties in translating generic strategic objectives into goals aligned with the portfolio of collaborative projects. These difficulties were reflected in the resulting confusion towards the primary goal of developing satellites. If the prevailing goal was ‘satellite application’, then appropriate strategies should have stressed downstream activities; for instance, through delivering satellite and satellite image utilisation. Moreover, a highly risk-averse approach should have been adopted as the commitment to end-users should be prioritised (e.g. the categorical need to deliver satellite images to end-users). On the other hand, if the prevailing goal was ‘satellite technology learning’, suitable strategies should have stressed design, manufacture and integration of satellite systems. Learning how to build satellites is the priority in these strategies. Higher risk should have been accepted, as learners are still building capabilities and skills.

By not prioritising objectives, the Algerians could not adopt clear goals and strategies. This led to confused direction being fed through to lower levels of management, researchers and engineers. The failure to define clear goals is also reflected in opaque requirements regarding the capability to be built and the technology to be developed. The study reveals that the technology transferor in collaborative projects adopted a stance that ranged from flexibility, when transferring technology that has been exploited up to its limits and can be transferred without any risk, to rigidity, when transferring new and advanced technology. Acquisition of a variety of technologies, each with its own level of complexity and maturity, is virtually impossible for a resource-limited organisation such as CSD. There is, therefore, a need to define clearly which technologies to target (e.g. system or subsystem) and which capability to build (e.g. design, development or integration).

The observed confusion in clearly defining objectives reflects the non-alignment of CSD’s goals and strategy with the collaborative projects (or project portfolio). Ideally, projects should be premised on CSD’s goals and be embedded in strategy. If the goals are not clearly defined and the strategy not well thought through, it is difficult to know whether collaborative projects are the right projects, whether they are in conformance with the strategy and whether they meet the stated objectives.

Algerians therefore need to dissociate the strategic objective of ‘satellite technological learning’ from that of ‘satellite application’. There is also a need to clearly prioritise the objective of ‘technological learning’ for small satellite capability-building. This should remove confusion as to the appropriate implementation mechanisms to adopt. It implies that larger risk margins are acceptable and lower management levels, engineers and researchers would be more learning-focused and risk-tolerant or risk-disposed. Prioritising technological learning also implies clear identification of the technologies to be targeted. It is recommended that the Algerian space agency develop market segments requiring less sophisticated technology, and concurrently channel efforts towards developing less sophisticated technology.

This article is one of a small number of empirical research reports addressing, at a finer level of aggregation, satellite technology transfer in developing countries. The proposed model focused on the objective of ‘learning’ during the project through the joint management mechanism adopted by both the transferee and the transferor, and was tested within the setting of small satellites in Algeria. However, it may also be applicable to other learning-focused

projects in different contexts, provided that it can be empirically tested, enriched and adapted through further research.

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Evaluation of 'learning' as a main thrust in transferor transferee relationships: small satellite technology transfer collaborative projects between developed and developing countries the case of Algeria

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2021-06-01

Intellect

https://doi.org/10.1386/tmsd_00037_1

Ayad A, Darby R, Matthews R. (2021) Evaluation of 'learning' as a main thrust in transferor transferee relationships: small satellite technology transfer collaborative projects between developed and developing countries the case of Algeria. International Journal of Technology Management and Sustainable Development, Volume 20, Issue 2, June 2021, pp.107-127