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Identifying design principles for business incubation in the European space sector

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ABSTRACT

Organizations and policy makers seek to support business and entrepreneurship through facilitating new product and service development, for instance in business incubators. Taking stock of existing research and combining this with practitioner's insights, this study aims to identify a comprehensive set of design principles for incubation practices in a particular sector, the European space sector. We provide a synthesis of business incubation practices, resulting in a set of actionable design principles that also serves to tailor solutions for other contexts.

1. Introduction

The impact of business incubators on successful business venturing has received increasing attention over the last decades (e.g., Albort-Morant and Ribeiro-Soriano, 2016; Baraldi and Ingemansson Havenvid, 2016; Bruneel et al., 2012). Incubators typically seek to provide a nurturing setting (Bøllingtoft and Ulhøi, 2005; Markovitch et al., 2017) and a sheltered environment (Allen and Rahman, 1985) by actively ensuring that start-up firms get resources, services, and assistance (Vanderstraeten and Matthyssens, 2012). Incubation centers, accelerators, and business support brokers may play important roles in finding new entrepreneurial opportunities and are considered as strategic actors for early entrepreneurial activities (e.g., Albort-Morant and Oghazi, 2016; Mas-Verdú et al., 2015; Patton, 2014; Pauwels et al., 2016; Schwartz, 2013). They can facilitate early product development (e.g., Bøllingtoft and Ulhøi, 2005; Patton, 2014), promote nascent entrepreneurship in particular industrial sectors and regions (e.g, Abetti, 2004; Schwartz and Hornych, 2010; Sofouli and Vonortas, 2007; Thierstein and Wilhelm, 2001), support development of disruptive technologies (e.g., Barbero et al., 2014; Löfsten and Lindelöf, 2005; Roig-Tierno et al., 2015; Tsai et al., 2009), guide market entry (Rong et al., 2015), or support commercialization of products and services (e.g., Chen, 2009; Clarysse et al., 2005; Clausen and Korneliussen, 2012; Cooper and Park, 2008; Wonglimpiyarat, 2010). As a result, incubators can contribute to economic growth by boosting innovation and strengthening new entrepreneurial projects (e.g., Barbero et al., 2014; Roig-Tierno et al., 2015).

Yet, differences in organizational structures, practices and objectives of business incubation programs have hampered the development of a united conceptual framework for research on incubators (Albort-Morant and Ribeiro-Soriano, 2016). This not only hampers scientific understanding of incubators, but also hinders devising practical recommendations suitable for a specific context (cf. Berglund et al., 2018). Therefore, this paper focuses on developing design principles that can help to integrate the literature and help to redesign existing practices or design new solutions for incubation and technology transfer in specific contexts (Berglund et al., 2018; Romme and

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Table 1
Business incubation practices and mechanisms identified in the literature analysis.

Description of practices and services	Examples from contemporary literature
A. Providing access to facilities and financial resources	
Access to facilities - Access to professional services and shared resources with flexible space and affordable rents; - Access to equipment and infrastructure, laboratories, workshop space, conference facilities.	e.g.; Berbegal-Mirabent et al. (2015); Bøllingtoft (2012); Bruneel et al. (2012); Lai and Lin (2015); Ratinho and Henriques (2010); Schwartz (2013); Scillitoe and Chakrabarti (2010); Soetanto and Jack (2013); Somsuk and Laosirihongthong (2014); Wonglimpiyarat (2010).
Access to funding - Providing start-up with initial financing assistance and support; - Enhancing the access to venture capital.	e.g.: Lai and Lin (2015); Ratinho and Henriques (2010); Scillitoe and Chakrabarti (2010); Soetanto and Jack (2013); Somsuk and Laosirihongthong (2014).
B. Facilitating networking, brokering, and collaboration	
Strategic partnering and networking - Supporting strategic networking and access to events; - Enhancing cooperation with mature or large enterprises; - Intensifying industrial relations and international institutions networks; - Mediation of the incubation process; - Supporting business alliances and access to business contacts.	e.g.: Bøllingtoft (2012); Bruneel et al. (2012); Lai and Lin (2015); Mian et al. (2016); Ratinho and Henriques (2010); Schwartz (2013); Scillitoe and Chakrabarti (2010); Wonglimpiyarat (2010).
Alumni networking - Supporting collaboration with current and former alumnae, including post-incubation collaboration; - Supporting incubation experience consultancy; - Acting as a forum to create a dissemination of knowledge.	e.g.: Carayannis and Von Zedtwitz (2005); Grimaldi and Grandi (2005); Hackett and Dilts (2004); Lai and Lin (2015); Zedtwitz and Grimaldi (2006).
Brokering - Identifying new technology or market opportunity activities, - Networking with potential customers and partners; - Increasing awareness among entrepreneurs; - Dissemination of technology, product, or service information; - Creating and connecting business angels' network and fostering of new technology transfer activities.	e.g.: Bruneel et al. (2012); Clarysse et al. (2005); Ratinho and Henriques (2010); Sofouli and Vonortas (2007).
Collaboration with start-ups - Supporting with management and administrative or customized service of tenant companies; - Establishing selection process of the tenants and admission rules, including the exit policy; - Assisting in horizontal (competition for customers) and vertical (up-stream and down-stream) collaboration; - Engaging in the services of incubated companies.	e.g.: Bergek and Norrman, 2008; Bøllingtoft (2012); Bruneel et al. (2012); Cooke et al. (2006); Etzkowitz et al. (2005); Grimaldi and Grandi (2005); Lai and Lin (2015); Ratinho and Henriques (2010); Soetanto and Jack (2013); Sofouli and Vonortas (2007); Somsuk and Laosirihongthong (2014).
C. Enhancing regional, national and industrial embeddedness	
Clustering - Stimulation of endogenous growth and regional strength; - Improvement of location factors for entrepreneurship and regional economy development, including geographic proximity market, research centers, or universities; - Faster integration and application of research resources and technology transfer within regional innovation clusters and high-technology agglomerations; - Attracting local human capital and skills; - Supporting emergence of complementary industry.	e.g.: Cooper and Park (2008); Chan and Lau (2005); Grimaldi and Grandi (2005); McAdam and Marlow (2007); Ratinho and Henriques (2010); Schwartz and Hornych (2008); Sofouli and Vonortas (2007); Tsai et al. (2009).
National technology policy - Exploitation of research and technological services in the region; - Promotion and support sustainable local and regional development; - Supporting expansion of employment and knowledge intense sectors; - Supporting national economic and innovation systems development; - Dissemination and support of government technology and business policy.	e.g.: Bruneel et al. (2012); Lai and Lin (2015); Lee and Osteryoung (2004); Roig-Tierno et al. (2015); Sofouli and Vonortas (2007); Tsai et al. (2009).

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Table 1 (*continued*)

Description of practices and services	Examples from contemporary literature
Market credibility - Improving credibility and support of new potential products and technologies of start-ups during their development and incubation process; - Supporting flexibility in research, technology or product development accordingly to the current market or industrial sector needs. - Improving the start-ups credibility by developing of self-sustaining and thriving companies. - Enabling buyers and sellers to interact.	e.g.: Bøllingtoft and Ulhøi (2005); Bruneel et al. (2012); Cooke et al. (2006); George et al. (2002); McAdam and Marlow (2007); Schwartz (2013); Somsuk and Laosirihongthong (2014); Totterman and Sten (2005).
Public Relations - Public awareness creation and promotion of the incubator organization into the market place; - Enhancement of the tenant's public visibility and credibility; - Advertising and attention, including *trans*-regional visibility; - Supporting to build-up company image and community-related effects; - Organizing press conferences and supporting the public outreach of incubated start-ups.	e.g.: Bøllingtoft and Ulhøi (2005); Chan and Lau (2005); Clarysse et al. (2005); Chan and Lau (2005); Ratinho and Henriques (2010); Schwartz and Hornych (2008); Sofouli and Vonortas (2007); Tsai et al. (2009).
D. Supporting technology and product development *Technology and product development* - Focusing on product, technology or service commercial capability - Acceleration of new dynamic technology and companies; - Improving the start-up competence, skills and technology validation.	e.g.: Bøllingtoft and Ulhøi (2005); Bruneel et al. (2012); Carayannis and Von Zedtwitz (2005); Chen (2009); Clarysse et al. (2005); Cooke et al. (2006); Cooper and Park (2008); M. McAdam and Marlow (2007); Sofouli and Vonortas (2007); Wonglimpiyarat (2010).
E. Facilitating technology protection and transfer *Intellectual property* - Securing access to specific intellectual property and licensed technologies; - Providing intangible assets service (IP assessment, advising and protection); - Supporting patent citations, absorptive capacity and incubator firm performance.	e.g.: Bruneel et al. (2012); Clarysse et al. (2005); Cooke et al. (2006); Lai and Lin (2015); Rothaermel and Thursby (2005); Scillitoe and Chakrabarti (2010); Sofouli and Vonortas (2007).
Licensing of technology - Mediating the licensing process of new technology and complement existing technology; - Securing exclusive licensing of novel technology of start-ups.	e.g.: Clarysse et al. (2005); Cooke et al. (2006); Marlow and Mcadam (2015); McAdam and Marlow (2007); Rothaermel and Thursby (2005).
Rules and procedures - Supporting start-up's alignment with sectoral or industrial norms, regulations and procedures; - Providing consultancy, including e.g. insurance, services in accounting and other legal matters.	e.g.: Bergek and Norrman, 2008; Bøllingtoft and Ulhøi (2005); Carayannis and Von Zedtwitz (2005); Lee and Osteryoung (2004).
F. Supporting venture development *Business modelling* - Assistance in developing marketing plans; - Concentration of entrepreneurial efforts on narrow defined market segments and market focused strategy; - Help with future opportunity search and recognition; - Sensitizing researchers to market needs, including marked-oriented form of networking and strategies.	e.g.: Bøllingtoft and Ulhøi (2005); Clarysse et al. (2005); Cooper and Park (2008); Grimaldi and Grandi (2005); Lai and Lin (2015); Pauwels et al. (2016); Ratinho and Henriques (2010); Schwartz and Hornych (2008); Scillitoe and Chakrabarti (2010); Sofouli and Vonortas (2007).
Mentoring and business support - Providing with professional management services and building up management teams; - Diagnose of business needs; - Encouraging the formation and growth of knowledge-based business of resident start-ups; - Entrepreneurial counselling and training; - Education in leadership marketing and sales;	e.g.: Bøllingtoft (2012); Bergek and Norrman, 2008; Chan and Lau (2005); Clarysse et al. (2005); Cooke et al. (2006); Grimaldi and Grandi (2005); Lai and Lin (2015); Mian et al. (2016); Ratinho and Henriques (2010); Schwartz and Hornych (2008); Schwartz (2013); Scillitoe and Chakrabarti (2010); Somsuk and Laosirihongthong (2014).

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Table 1 (*continued*)

Description of practices and services	Examples from contemporary literature
- Providing competition assessment and business management designs; - Education in executive strategy, including staff and team composition.	
Training - Providing in-house experts hands on assistance, including R&D activities and technology or product development; - Support and assistance in knowledge management and technology transfer; - Supporting cultivation and incubation of knowledge; - Securing human resources and personnel with expertise; - Establishing capabilities for entrepreneurs faster learning and creation of solutions to problems; - Technical support and consultation, including coaching.	e.g.: Bruneel et al. (2012); Lai and Lin (2015); Ratinho and Henriques (2010); Somsuk and Laosirihongthong (2014); Soetanto and Jack (2013); Wonglimpiyarat (2010).
Progress monitoring - Providing monitoring and validation of the tenant performance; - Demands for verification of the tenant performance during the incubation period; - Establishing milestones with clear policies and procedures.	e.g.: Bruneel et al. (2012); Cooke et al. (2006); Lai and Lin (2015); Sofouli and Vonortas (2007); Somsuk and Laosirihongthong (2014).

Reymen, 2018; Van Burg and Romme, 2014). The main research question is: What are the key elements of design principles for business incubation according to the literature and how are these design principles contextualized in space sector incubation practices?

Design principles prescribe possible changes to achieve certain aims (Baldwin and Clark, 2000; Romme and Endenburg, 2006) in the form of context-specific and pragmatic heuristics that explain that "to achieve Y in situation Z, then something like action X will help" (Van Aken, 2004, p. 227). These principles should ideally draw on both scholarly knowledge and practitioners' expertise (Van Burg et al., 2008). Underlying these design principles are generative mechanisms, as micro-theories of the 'how' and 'why' of the interventions proposed in the principle may work out as intended (Denyer et al., 2008; Van Burg and Romme, 2014).

The objective of this study is to provide design principles as hands-on tools for designing solutions that trigger key incubation mechanisms. This paper adopts a design science approach to link theory and practice (e.g., Berglund et al., 2018; Romme and Endenburg, 2006; Van Aken, 2004) and starts with a review of incubation practices from the existing body of literature as pointers towards underlying theoretical mechanisms. Next, following the design framework proposed by Van Burg et al. (2008), a couple of business incubators are studied to codify the emerged practical insights and to contextualize theoretical mechanisms. Finally, insights from both theory and practice are synthesized in a set of design principles.

This study provides a deeper understanding of key design principles of business incubation practices and contextual dependencies of these principles in the setting of the space sector. This set of design principles not only helps to design incubation solutions in this sector, but also enriches incubation theory with a coherent design framework. Next, following a similar approach, these principles can also be adjusted and become fruitful for designing incubation solution in other sectors.

2. Review of elements for business incubation design principles

The generalizability of insights on technology business incubators is limited, due to idiosyncrasies of the types of incubators and the lack of generalizable definitions of incubation practices. As a result, the literature is quite dispersed and unifying frameworks are lacking. Therefore, we use a pragmatic design science approach that has the potential to cut through different disciplines and paradigms in order to collect key insights from different streams of research.

This paper now turns to a review of business incubation practices. Following the design science approach, this study first presents a systematic literature review of the current body of knowledge. The review focused on collecting common elements for business incubation, as pointers to developing design principles and getting insights in underlying theoretical mechanisms. The results of this review form six clusters, representing six elements for business incubation design principles (see Table 1). The summary of selection criteria for including articles in this review is presented in Table 2. The studies were analyzed using systematic coding of practices and design

Table 2
Search and selection criteria of the literature.

Search destination	ProQuest, Science Direct, Web of Science
Journal impact factor selection	The Harzing Journal Quality List (18 April 2016, fifty-seventh edition)
Selection criteria	peer reviewed only
Publishing period	2000–2016
Key words	business incubation AND incubator AND incubation
Abstract criteria	Models and common key words determinants; business incubation conceptual and empirical studies
First selection	125 papers
Final selection for literature analysis	82

principles.

Providing access to facilities and financial resources. Provide access to facilities such as laboratories, meeting spaces, and affordable office space (e.g., Bruneel et al., 2012; Clarysse et al., 2005; Somsuk and Laosirihongthong, 2014), as well as initial financial assistance, including seed funding, venture capital investments, or bank loans (e.g., Chen, 2009; Schwartz, 2013; Scillitoe and Chakrabarti, 2010).

Facilitating networking, brokering, and collaboration. Facilitate access to events, and leverage cooperation with former tenants (Lai and Lin, 2015), with business angel networks (e.g., Peters et al., 2004; Ratinho and Henriques, 2010; Schwartz and Hornych, 2008), and mature enterprises and international institutions (Rice, 2002). Collaboration is fostered through shared activities and physical proximity (Cooper and Park, 2008).

Enhancing regional, national and industrial embeddedness. Regional clustering stimulates endogenous growth (e.g., Cooper and Park, 2008; Ratinho and Henriques, 2010; Tsai et al., 2009) and supports emergence of complementary industries (e.g., Peters et al., 2004; Ratinho and Henriques, 2010). Embedding nationally involves help with aligning with national technology policy, which increases opportunities for funding and technology dissemination (e.g., Bruneel et al., 2012; Lee and Osteryoung, 2004; Sofouli and Vonortas, 2007). Incubators can also support industrial and market embeddedness of new ventures (e.g., Chan and Lau, 2005; Clarysse et al., 2005; Ratinho and Henriques, 2010) as the promotion of the incubator organization and its tenants positively enhances public visibility and credibility.

Supporting technology and product development. Through tailor-made training and advice, as well as through their networks, incubators can help start-ups to develop product, technology or commercial capabilities (e.g., Soetanto and Jack, 2016; Wonglimpiyarat, 2010).

Facilitating technology protection and transfer. Securing access to intellectual property and licensed technologies can help new ventures to build up a sound technology basis and product range (e.g., Bruneel et al., 2012; Clarysse et al., 2005; Lai and Lin, 2015). Furthermore, incubators can support new ventures in the understanding and application of specific norms, regulations or procedures typical for the sector (e.g., Bergek and Norrman, 2008; Bøllingtoft and Ulhøi, 2005; Lee and Osteryoung, 2004), and provide services in accounting or legal matters (e.g., Clarysse et al., 2005; Schwartz and Hornych, 2008).

Supporting venture development. Venture development can be supported by mentoring and business support, for instance in helping building up a good management team (e.g., Chan and Lau, 2005; Zedtwitz and Grimaldi, 2006) or advising on setting up and aligning the different components and aspects of the venture, including market, supply, and value proposition aspects. Monitoring the progress of the tenant incubation helps entrepreneurs to reflect on their progress and to speed up if necessary (Bruneel et al., 2012).

In sum, despite the use of different theoretical lenses (e.g., Hackett and Dilts, 2004) like the resource based view (e.g., Somsuk and Laosirihongthong, 2014), transaction cost theory (e.g., Albort-Morant and Ribeiro-Soriano, 2016), social network theory (e.g, Nicolopoulou et al., 2016), or real options theory (Bergek and Norrman, 2008), many incubation studies suffer from a lack of 'grand theories' and comprehensive frameworks. Here, our review of elements for design principles provides an important start to get a comprehensive overview of underlying theoretical mechanisms that yields the promise to get to 'micro-theories' of business incubation (Van Burg and Romme, 2014).

3. Qualitative methodology

The qualitative part of the study aims to identify and codify managerial practices as well as their underlying mechanisms related to potential design principles (e.g., Denyer and Tranfield, 2006; Myers, 2013; Yin, 2013). This study focuses on incubation practices in the European space sector. This sector is a very specific setting, with a highly government-driven and regulated character, and recently business incubation gained traction in this sector. This study is gathering insights from both managers as well as start-ups at the ESA Business Incubation Centers (BICs) in Noordwijk and Harwell, and we compare these two similar cases to the semi-private UK government initiative Satellite Applications (SA) Catapult in Harwell. The ESA BICs depend on financial support by ESA through member state budget contributions. ESA BIC's are primarily focused on technology transfer from the space to non-space sectors, using space data and space-technology. In collaboration with other programs such as ESA's broker network, these centers partly work as 'brokers' which identify technologies in any industry and facilitate adaptation of space technology in other industries. The SA Catapult, on the other hand, is an independent, private innovation and technology development company established by the national UK innovation agency, partially also supported by public investments. Table 3 summarizes the three incubation programs.

Studying business incubation in the space sector is in particular interesting as business venturing in the space sector is facing a number of specificities. It requires access to relatively closed networks, to specific knowledge, high levels of standardization, and often demands high managerial workload. Entrepreneurs have to confirm to these specificities in to become suppliers of ESA and incumbent firms. This represents radical challenges for entrepreneurship, and incubators could play a role in dealing with these challenges.

Semi-structured interviews were conducted, accompanied by archival sources of particular business incubation organizations. Three related interview protocols were used, for representatives of start-ups, governmental institutions, and ESA interviewees. In total, forty-eight interviews were conducted. An overview of all interviews is presented in Table 4.

After collecting the data and transcribing the interviews, the text was inductively coded and clustered into twenty-one incubation practices. Next, these practices were connected to six design principles for incubation in the space sector.

4. Incubation design principles and practices in the European space sector

This section presents the results of the inductive analysis of the interviews. It focuses at respective business incubators' design

Table 3
Summary of the three space incubation programs in the Netherlands and the UK.

	ESA BIC NL	ESA BIC UK	SA Catapult UK
Ownership	- Public Organization (ESA) - Operated by external private entity (Space Business Innovation Centre)	- Public Organization (ESA) - Operated by external public entity (Science and Technology Facilities Council)	- Semi-private business company - Supported by Innovate UK agency
Funding	- ESA Member State contribution via General Support Technology Program (GSTP) - Direct government investment	- ESA Member State contribution via General Support Technology Program (GSTP) - Direct government investment	- UK government - Own commercial and R&D activities - Start-ups as clients
Facilities	- Office and space - ESA ESTEC Centre	- Office and space - STFC laboratories	- Office and space - Virtual space environment monitoring and 3D projection facilities - Satellite communication and security centers - Antenna test range
Prevailing type of incubation	- Technology incubation	- Technology incubation	- Business acceleration
Technology transfer direction	- Spin-out	- Spin-out	- Spin-in & Spin-out
Product and market orientation	- Preferably down-stream	- Preferably down-stream	- Up-stream & Down-stream
Services portfolio	- Incentive funding (€50 K) - Business development loan (€50 K) - ESA technical support (80 h) - IP Consulting - Business development & and financial administration support - Networking - Access to ESA technology facilities - Access to ESA Broker network	- Incentive funding (£40 K) - STFC Seed funding (£25–500 K) - Access to technology facilities - Business support - Networking - Access to ESA Broker network	- Business venturing collaboration - Mission platforms - Remote sensing - Data access - Local based services & communications - Applications solutions & use of data - Knowledge transfer & Research development - Business and design support - Market reporting
Technology transfer areas	- Navigation & mobile services - Earth observation - Transportation & communication - Agriculture - Energy sector - Robotics & Mechatronics - Materials	- Hardware & design development - Data gathering & services - Navigation & mobile - Communications - Earth observation - Energy sector - Agriculture & Urban planning	- Intelligent transport systems - Sustainable economy - Sustainable living - Platforms and information-based services - Government services
Number of start-ups	- 10 per year	- 10 per year	- Approx. 50 per year

Table 4
Empirical data collection.[a]

Informant's role	Code of Reference
Entrepreneur from ESA BIC in Noordwijk	NL_COMP2, NL_COMP3, NL_COMP_4, NL_COMP6a, NL_COMP6b, NL_COMP7
Entrepreneur from ESA BIC in Harwell	UK_COMP1, UK_COMP2, UK_COMP3, UK_COMP4, UK_COMP6, UK_COMP7, UK_COMP8, UK_COMP10
Non-affiliated/independent entrepreneur	NL_COMP1, NL_COMP5a, NL_COMP5b, NL_COMP8, NL_COMP9a, NL_COMP9b, NL_COMP10, UK_COMP5, UK_COMP9
Representative of the ESA BICs	NL_BIC_ESA1, UK_ESA1
Representative of the SA Catapult	UK_SAC1, UK_SAC2, UK_SAC3, UK_SAC4
Representative of the government agencies	NL_GOV1, NL_GOV2a, NL_GOV2b, UK_GOV1, UK_GOV2, UK_GOV3, UK_GOV4
Representative of the European Space Agency	ESA_CSPO1, ESA_NMS1, ESA_POL1, ESA_POL2, ESA_POL3a, ESA_POL3b, ESA_SPC1, ESA_TTPO1a, ESA_TTPO1b, ESA_TTPO2, ESA_TTPO3

[a] Abbreviations: BIC: Business Incubation Centre; COMP: Company; CSPO: Corporate Strategy Policy Office; ESA: European Space Agency; GOV: Governmental Agency; NL: The Netherlands; NMS: New Member States Office; POL: Policy Office; SAC: Satellite Applications Catapult; SPC: Strategic Planning Coordinator; TTPO: Technology Transfer Program Office; UK: United Kingdom.

principles and the practices through which these design principles are implemented in the cases we studied. The summary of design principles and related practices is presented in Table 5. Practices observed in the three cases are presented in Table 6. Thus, the main aim of this section is to find out whether the incubation practices in the space sector are aligned with the incubation elements previously identified practices in literature and how these incubation elements are contextualized in the space sector.

Table 5
Synthesis of business incubation design principles and practices in the space sector.

Design Principle	Practices Pointing at Design Solutions	Empirical description from the case studies
1. Generate awareness for new entrepreneurial opportunities	- Commercial *viability*	The incubator helps to assess commercial viability - in a broader perspective of national and European markets – through market analysis and feedback to find an opportunity that has the potential for a long-term contribution to the future success of the venture and supports the competitive position of the company and its product.
	- *Market orientation*	Orienting on down-stream applications and/or up-stream markets by giving information on the existing players and supply chain. The incubator also gives information and exemplars for applications in non-space technologies and applications as disruptive innovation usually occurs in commercial and non-ESA affiliated business environments.
	- *Collaboration with start-ups*	Affiliation to the incubator and its network gives new ventures early experience in business and helps see new opportunities.
2. Increase product development capability and provide resource access	- *Access to intellectual property*	Providing and securing access to and utilization of ESA-related patents gives the ability to access protected technology and enhances the efficiency and quality of technology-transfer.
	- *Licensing of technology*	Supporting start-up's product or technology licensing secures the competitive position of the incubate.
	- *Data access*	Free or easy access to space assets and utilization of these data for applications is crucial for product development.
	- *Seed funding*	Providing initial business venture funding or facilitating a loan partnership with banks enable risky product development and increases venture survival chances in the short run.
	- *Access to facilities*	Offering working space (offices or laboratories) and access to technological facilities of associated research centers and institutions enables prototyping and reduces start-up costs.
3. Develop venturing skills	- *Training*	Expertise support and training in business development skills (e.g., business model design, marketing and sales) provides an important advantage for new ventures.
	- *Mentoring*	Professional mentoring by diverse experts helps to reflect on venture and product development and identify strengths, weaknesses and new opportunities, strengthening technology transfer, innovation and product quality.
	- *Progress monitoring*	Conducting frequent progress reports on product development supports early identification of potential product development or technology transfer obstacles and provides a vital tool for self-reflection and self-regulation. Properly defined duration of the incubation period and exit strategy provide new ventures sufficient time but also helpful progress- and time-pressure for necessary technology transfer, product development and business strategy preparations.
4. Enhance collaborative networking	- *Clustering*	Geographical proximity of business incubation facilities and technology centers contribute to vital collaboration between the incubates. It also provides access to and diversification of resources.
	- *Strategic partnering*	Horizontal collaboration between companies supports technology transfer partnerships between new ventures. It fosters the creation of future strategic alliances for innovation.
	- *Institutional market participation*	Incubator-facilitated collaboration with ESA and government-led programs provides vital experiences and prestige for companies.
	- *Brokering*	The incubator's brokering with venture capitalists and other potential key partner strengthens start-up's post-incubation position.
	- *Alumni networking*	Networking during and after the incubation period gives companies a strong network with comparable peers.
5. Familiarize with norms and exemplars for successful venturing	- *Rules and procedures*	Early support in aligning with rules and procedures in the space sector provides important understanding of established policies and regulations. It also decreases the managerial, bureaucratic, and technological constraints in future collaboration in the sector.
	- *National technology policy*	Alignment with national strategic objectives or technology roadmaps strengthens start-ups' ability to spin-in or spin-out of technologies. It also supports their particular interest in technology and development as they get access to funding as part of the roadmap programs.
6. Develop company reputation and product legitimacy	- *Public relations*	The public relationships and outreach of the incubator give the incubated business ventures the ability to draw on the reputation of the incubator and affiliated organizations (e.g., ESA) thus enhancing their future position in market and business collaboration.
	- *Legitimacy*	By being part of an ESA-related incubation program, product and company legitimacy and compliance with existing procedures and norms is enhanced.
	- *Lobbying*	The incubator's active lobbying and communication with for instance national government representatives increases the firm's reputation.

Table 6
Design principles and practices observed in the three cases.

Design principle	Practices	ESA BIC NL	ESA BIC UK	SA Catapult UK
*1. Generate awareness for new entrepreneurial opportunities**	- *Commercial viability*	Acts as facilitator, potential for further development	Acts as facilitator, potential for further development	Implemented by searching for new commercial applications and sectors
	- *Market orientation*	Focus on transfer of space technology, creating market value in other sectors	Focus on transfer of space technology, creating market value in other sectors	Focus on value creation inside and outside the space sector, through business relationships
	- *Collaboration with start-ups*	Facilitator only, further potential for development to become a co-creator	Facilitator only, further potential for development to become a co-creator	Implemented via business partnership
2. Increase product development capability and provide resource access	- *Access to intellectual property*	Independently by incumbents	Independently by incumbents	Limited access
	- *Licensing of technology*	Licensing as business model is not supported	Licensing as business model is not supported	Receives support
	- *Data access*	Free to ESA Database	Free to ESA Database	Provided from multiple resources
	- *Seed funding*	Available	Available	Limited
	- *Access to facilities*	Collaboration with ESTEC, further diversification outside ESA is an option	Access via other space related R&D facilities	Access to multiple facilities
3. Develop venturing skills	- *Training*	Additional entrepreneurial training is an option for further development	Additional entrepreneurial training is an option for further development	Implemented
	- *Mentoring*	Local and ESA experts provided	Local and ESA experts provided	Limited by external partnerships
	- *Progress monitoring*	Implemented	Implemented	Based on partnerships
4. Enhance collaborative networking	- *Clustering*	Regional and established facility proximity but distant from other sectors	Regional and established facility proximity but distant from other sectors	Regional and established facility proximity but distant from other sectors
	- *Strategic partnering*	Potential for further development as co-creator	Potential for further development as co-creator	Implemented via business partnerships
	- *Institutional market participation*	Limited in objective, focuses on technology transfer from space to non-space sectors	Limited in objective, focuses on technology transfer from space to non-space sectors	Commercial focus
	- *Brokering*	Technology brokering, less business focus	Technology brokering, less business focus	Both for the technology as well as for the business
	- *Alumni networking*	Established and provided	Established and provided	Established via the former business ties
5. Familiarize with norms and exemplars for successful venturing	- *Rules and procedures*	Active alignment and implementation	Active alignment and implementation	Active alignment
	- *National technology policy*	Collaboration with ESA member state government	Collaboration with ESA member state government	Alignment to national innovation policy and commercial interests of private and public stakeholders
6. Develop company reputation and product legitimacy	- *Public Relations*	Active, positive impact of ESA BIC affiliation	Active, positive impact of ESA BIC affiliation	Active
	- *Legitimacy*	Compliance with existing procedures	Compliance with existing procedures	Supports conformance to established practices including support of innovative approaches
	- *Lobbying*	Room for more pro-active lobbying	Room for more pro-active lobbying	Limited to commercial and specific sector or technology interests

4.1. Generate awareness for new entrepreneurial opportunities

This first empirical cluster presents findings around practices that generate awareness for new entrepreneurial opportunities. These findings can be related to the literature aggregated in cluster B (Table 1) on strategic partnering and networking as well as to some literature from cluster F on business modelling and training.

Commercial viability. Developing an innovation idea related to space technology requires a long-time span which often decreases the commercial viability of the product. Therefore, a key task of the ESA BICs is to help start-ups with their technology development and to enhance commercial viability. Supported by ESA's broker network, the transfer process extracts and markets space technologies, services and applications by analyzing the needs of non-space applications and identifying suitable space technologies to meet these needs. Yet, the SA Catapult has a stronger focus on supporting commercial viability. “What we are trying to do is to have a number of target market areas where we think where space technology has proven to be a significant enabler” [UK_SAC4].

Market orientation. ESA BIC's incubation program helps to overcome mental barriers for newcomers, especially in orienting towards potential markets. New start-ups may fully focus on technology development, but often not yet on the business side of their venture. The

role of the ESA incubators is to support developing this business thinking. SA Catapult is going a step further towards commercial opportunities. SA Catapult tries to facilitate collaboration between small and large businesses, building up new business connections and creating opportunities for future potential customers. They do so through collaborative projects, acting as a R&D organization and this often helps to find new markets.

Collaboration with start-ups. ESA BIC provides basic support such as office space or access to various technology facilities, but does not necessarily collaborate on projects with start-ups. The application process for collaboration between ESA BIC and start-ups is constrained by ESA procurement procedures. SA Catapult goes further and offers sales support to the ventures, helps to find technical expertise, looks for connections in the sector and industry, and provides a collaborative and commercial funding scheme.

4.2. Increase product development capability and provide resource access

These case-based findings centre on practices that increase product development capability and provide resource access. They relate to literature in cluster E (Table 1) on facilitating technology protection, cluster D on supporting technology and product development, and cluster A on providing access to facilities and financial resources.

Access to intellectual property. ESA owns the IP of ESA-funded technology but shares it with the technology developer, and ESA is willing to support re-use of the technology and to share it with entrepreneurs. To smoothen the technology transfer process from the space sector, applicants to ESA BIC have to submit a technology transfer plan, indicating what kind of patents or licenses are planned to be used. The ESA broker network plays an important role in identifying new and niche technologies, products and applications, including the potential use of ESA's or another party's IP. In contrast, at SA Catapult, any IP generated from projects remains property of the company. SA Catapult may ask for a limited IP license or non-commercial (R&D) license if needed for further projects. If the IP is generated together under a collaborative project with SA Catapult, the IP license is shared between the partners.

Licensing. Licensing technologies is important to introduce new space technologies into a commercial (non-space) environment. Especially the SA Catapult focuses on licensing: "We do a lot more licensing than we do patenting" [UK_SAC4]. SA Catapult is assisting companies to develop technologies and subsequently licensing some of those technologies to other companies. The ESA BIC's do not directly assist in licensing of technology developed by start-ups: "We encourage industry to take up the patents and then to make those patents available and do business with space and non-space (entrepreneurs)" [ESA_TTPO2].

Access to facilities. Access to ESA establishments is very important, as well as the technical support by ESA experts. Yet, several entrepreneurs expressed concerns that there is no real commitment from ESA staff. "The barrier now is that the entrepreneurs have to describe very thoroughly why is it relevant that they perform their tests at ESA facilities" [NL_ESA_BIC1]. Moreover, start-ups from ESA BIC face stringent security measures to access ESA facilities. In contrast, in the Harwell Cluster, a campus where both SA Catapult as well as ESA BIC are situated, facility access may be as simple as providing office space or even just a desk for a limited amount of time to a start-up in a very early stage.

Seed funding. As an entrepreneur said, seed funding is "very important unless you have a product that is (…) immediately able to be paid [for]" [UK_COMP4]. The seed funding, according to ESA BIC, should be spent mainly by doing research and working with equipment and cannot be used for office rents, business plans, or anything that could be covered by internal resources. Yet, incubates can combine seed funding from ESA BIC with funding from other ESA programs. At ESA BIC, the incubates can get another €50.000 as a bank loan.

4.3. Develop venturing skills

Here, we present practices that support the development of venturing skills. These findings primarily relate to literature from cluster F (Table 1) on supporting venture development.

Training. Training is often helpful, in particular for the commercial side of the ventures. "An issue is how do you sell it. This is where most of the companies have the problem" [ESA_TTPO1a]. Therefore, ESA BICs provides start-ups with a so-called investor-readiness program. Such a program provides training in accessing potential investors, provided by those potential investors themselves, as well as hands-on introductions to IP-management, accounting or marketing. SA Catapult supports new entrepreneurs in similar ways.

Mentoring. For many start-ups, mentoring is a crucial part of the business incubation program. ESA BICs, for example, provide technical mentoring by ESA experts. In particular, "they use the knowledge in Noordwijk to guide the firms that are located in ESA BIC Noordwijk" [NL_COMP6a]. Stressing its importance, other tenants actually lacked professional mentoring. "I think what is missing at present is that there is no directing kind of mentoring" [UK_COMP9]. SA Catapult provides experts from other governmental agencies.

Progress monitoring. Progress monitoring is a constitutive part of ESA's business incubation programs and its main purpose is to track the incumbents' progress in their business and technology development. "Unless we demonstrate our progress we do not get any funding" [UK_COMP10]. Progress reports include information on technology or product development, how time and resources were used, on further planning, and on financial resources the start-up has used and planning to use. Despite positive aspects like enhancing reflection on progress, such reporting requirements may also be a bureaucratic burden.

4.4. Enhancing collaborative networking

This section presents findings related to the design principle of enhancing collaborative networking. These findings connect to literature in cluster B (Table 1) on facilitating networking, brokering and collaboration, as well as cluster C on enhancing regional, national and industrial embeddedness. The practice of institutional market participation is unique for the space sector.

Clustering. Clustering and proximity to relevant business and institutions spur the creation of quality ideas and concepts. For example, the reason of establishing the ESA BIC and SA Catapult in the Harwell Space Gateway cluster was because of the existing located expertise and facilities (e.g., RAL Space, STFC facility), which provides an attractive environment for other business. Similarly, at ESA BIC in Noordwijk it is an important advantage to have ESA's ESTEC development facility at close proximity. It gives access to many sorts of science and technology development, as well as to knowledge and developing techniques, and spurs understanding of what space technology is.

Strategic partnering. Collaboration supports technology development and efficient production. The role of the business innovation teams in the BICs is to develop relationships with other organizations among which a strategic connection to ESA, which is crucial for many space-oriented new ventures. The SA Catapult is doing joint projects with space companies and non-space companies to help share, transfer or deliver information and awareness. In contrast, ESA BIC managers wait for the established industry to take their responsibility in fostering collaboration.

Institutional market participation. In Europe, government support is one of the main drivers of space sector development. "80% of the revenues of industry comes from institutional clients, and among the institutional clients ESA is the biggest one" [ESA_POL2]. Thus, governments or governmental organizations like ESA act very much as a facilitator in the space area, and for instance stimulates big companies to collaborate with SMEs on ESA tenders. Also, SA Catapult helps to link up to national strategic initiatives.

Brokering. We distinguish technology and business brokering and observe that, in collaboration with ESA's broker network, ESA BICs focus their attention more on technology than business brokering, while the latter is more evident in SA Catapult. ESA established a network of technology brokers across its member states to assess market needs in areas with potential for applying space technologies. ESA BIC brokers access to technical expertise. SA Catapult, as a semi-private venture activity, engages more in business brokering. They organize monthly networking events and the Supply Chain event for UK Space, enabling SMEs to meet the big companies in the space sector.

Alumni networking. Both ESA BICs and SA Catapult facilitate networking with alumni who have experiences of how to manage the equity investment process, how to get products into the market and develop sales. Interaction with alumni is deemed important, as "there is nothing quite like hearing things first-hand from someone who has been through the pain, so the people do not suffer the same pitfalls" [UK_BIC_ESA1].

4.5. Familiarize with norms and exemplars for successful venturing

A number of practices point at the design principle on familiarizing with norms and exemplars for successful venturing. These findings can be connected to literature in cluster C (Table 1) on market credibility and national technology policy, and to literature in cluster E on rules and procedures.

Rules and procedures. New business ventures in the space sector often have difficulties to align with the sector's many and tight procedures. This is something where the incubators prove to be important to the new ventures, also by pointing at exemplar companies. ESA BICs, for example, apply the ESA style of procurement and monitoring. Thus, once start-ups collaborate with ESA BICs, they get familiar with and aligned to the space sector's processes.

National technology policy. Due to the central role of governments in the space sector, alignment to national technology policy is vital, and sometimes crucial for business success. Both the Dutch an UK government have created national technology development roadmaps, and provide funding aligned with these roadmaps. Yet, some entrepreneurs are confused by the multiple priorities reflected in these roadmaps. "A current set of 14–15 roadmaps with many topics does not lead to a focused allocation of resources" [NL_COMP5b].

4.6. Developing company reputation and product legitimacy

This last empirical cluster presents practices related to developing company reputation and product legitimacy. These findings connect to literature in cluster C (Table 1) on public relations and market credibility, while the practice of lobbying is rather novel.

Public relations and outreach. Affiliation to ESA BICs or space-oriented business clusters such as the Harwell Cluster provides new companies with a positive image which strengthens a company's outreach possibilities. "You do not get much better publicity than to have your company affiliated with an ESA incubator" [UK_COMP10].

Legitimacy. The incubator has a crucial role in increasing the legitimacy of the incubates by aligning new entrepreneurs with the nuances of the space industry already during the early stage of their venture. Small and medium-sized enterprises and start-ups are often seen as a big risk to collaborate with, especially by large organizations such as ESA. "You just need to work hard, and you need to build trust, and listen to ESA. Once there is a trusted relationship it opens doors to continue and to collaborate in other projects" [NL_COMP1].

Lobbying. Lobbying in the space sector is done between companies and governments, between governments and governmental organizations, and between the different companies, including the small and large industrial players and incubators. National delegations are the stakeholders of ESA and are responsible for making decisions about the main directions of ESA and, at the end, should take particular care for return on investments to their national industries. Although companies are consulted in the creation of national technology roadmaps or future strategies, some expressed that national policy-makers should be more pro-active in advertising the small companies to the broader community of industrial representatives.

5. Discussion

To address our research question, we first focused on identifying key elements of design principles for business incubation according

to the current literature, and next we analyzed how these elements relate to contextualized business incubation practices in the space sector. Subsequently, we turned these findings into design principles for business incubation in the space sector using the qualitative case analysis, and we describe important practices for each of them as practical helps for designing solutions. Each of these design principles and related practices provide actionable design interventions with key insights in what an incubator does, but more importantly, they add understanding of why (and when) incubators can have an effect on the tenants.

As such, these six design principles form a contribution to understanding business incubation, which is hindered by the lack of unified theoretical frameworks. Our results synthesize concepts of business incubation practices in a coherent and comprehensive set of six design principles and related practices, pointing at underlying theoretical mechanisms that could integrate the literature and cut through different research paradigms and traditions (cf. Van Burg and Romme, 2014). Next to that, each of the principles have its own potential to provide new insights. In particular, our study shows that in a highly institutionalized setting incubation practices that add to developing legitimacy, as well as practices that help to familiarize with this setting, are very important. This calls for further development of these aspects in research on business incubation, attending to developing reputation and legitimacy, building on established theories that address this mechanism already in general (e.g., Cornelissen and Clarke, 2010; Markard et al., 2016; Suchman, 1995; Zimmerman and Zeitz, 2002).

By choosing the space sector as a specific research setting we found new practices, pointing at lesser explored mechanisms. First, the incubator's support of institutional market participation plays an important role for new ventures in accessing rather restricted government-led markets. As a such, incubators should strengthen their support for brokering new opportunities and partnerships (e.g., Aernoudt, 2004; Albort-Morant and Oghazi, 2016). Moreover, a specific practice in the space sector relates to securing unique data access, such as data created and owned by ESA, which could be strengthened as well.

Moreover, our design principles provide important practical insights, and they can easily be used by practitioners to design their own contextual solutions. The six design principles help to (re)design technology business incubation programs (see for instance Table 6 for an application to the three cases). The practices reviewed from the literature and described from our three cases provide sufficient examples of how detailed solutions can be designed in a particular context (Autio et al., 2014; Bamberger, 2008; Garud et al., 2014). In particular, the results from this study suggest that business incubators in highly institutionalized sectors should focus more on assessing and increasing commercial viability of products, technologies or services. Moreover, incubators can help with easy access to test- and development facilities and focus more on business brokering with companies and organizations outside the (space) sector to enable a smooth launch of the incubates. Similarly, the six design principles and constituent practices can help to (re)design incubation and technology transfer solutions in other settings.

This study has two specific limitations that we want to discuss. First, we only studied three business incubators in two countries. The variety of mechanisms and practices could be different across different incubators, also among ESA BICs, as each of these incubators have their own idiosyncrasies. In order to establish the empirical generalizability of our findings, similar studies need to be conducted in other countries, with different governmental structures, public interests, or space sector traditions. Second, we focused on the space sector as the context for our study, and our findings might be particularly applicable to that sector or other sectors with similar characteristics. Key characteristics of the space sector are the role of government support and intra-governmental regulations, as well as the fact that most technology development is medium to high-tech and capital intensive. A comparative analysis with other similar – as well as dissimilar – sectors and industries is important to establish similarities and differences in business incubation practices. In particular, we find that in the space sector mechanisms related to legitimacy and familiarizing are crucial, given the highly institutionalized character of this sector. Thus, studying other technology sectors with much government influence like the aerospace or energy sector could help to identify the boundary conditions of our findings and bring deeper understanding to the identified business incubation design principles.

6. Conclusion

This study contributes detailed observations of incubation practices and provides important pointers to the underlying theoretical mechanisms found in literature. This study shows that business incubators facilitate mechanisms related to entrepreneurial opportunities, resources, networks, capabilities, and legitimacy. The success of the incubation process is, therefore, influenced by many aspects, most importantly by the enactment of incubation practices. The results of this study point to a need to consider sectoral and contextual differences in business incubation practices in order to enrich understanding of technology business incubation.

Statement conflict of interest

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