AMBIDEXTERITY AS HISTORICALLY EMBEDDED PROCESS: EVIDENCE FROM NASA, 1958-2016

Loizos Heracleous
Professor of Strategy and Organization
Warwick Business School
University of Warwick
Coventry CV4 7AL
United Kingdom
loizos.heracleous@wbs.ac.uk

Carlos Yniguez
Managing Director
mydays GmbH
Zielstattstr. 21-23
81379 Munich
Germany

Steven Gonzalez
Technology Transfer Strategist
Johnson Space Center
NASA
Houston, TX
United States

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Abstract

Even though the growing ambidexterity literature has delivered useful insights, this theme has been researched largely in static and a-contextual terms, without adequate attention to how an organization's history and context can shape its present. In this paper we employ NASA as an in-depth case study to trace how its historical trajectory has shaped its current propensity to be ambidextrous. Our study reveals organizational ambidexterity as a path-dependent, contingent process rather than something necessarily achievable via the more generic prescriptions of structural, temporal or contextual ambidexterity models.

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Introduction

The need to deal with contradictory and even paradoxical tensions is endemic to the fabric of organizations (Lewis, 2000; Papachroni, Heracleous & Paroutis, 2015). For instance, organizations have to functionally differentiate, but also integrate their design and processes; they have to institute control, but also empower and energize people; and they have to exploit current resources and capabilities, but also explore and develop new ones for the future (Abell, 1999; Cameron, 1986; March, 1991).

Ambidexterity research has grown substantially over the last two and half decades (O'Reilly & Tushman, 2013). Prescriptions for accomplishing ambidexterity include structural separation of exploratory from exploitative units (O'Reilly & Tushman, 1996; Tushman & O'Reilly, 2004), temporal separation in terms of a punctuated equilibrium between longer periods of exploitation and shorter periods of exploration (Romanelli & Tushman, 1994; Siggelkow & Levinthal, 2003), and building a supportive but stretching context that allows employees to decide for themselves whether to focus on exploitation or exploration activities depending on the situation (Birkinshaw & Gibson, 2004; Gibson & Birkinshaw, 2004).

Despite the expanding literature however, scholars have noted that ambidexterity has been researched largely in static and a-contextual terms (Raisch & Birkinshaw, 2008; Simsek et al., 2009), without adequate attention to how an organization's history and context can shape its present, and in particular its ongoing propensity to accomplish organizational ambidexterity. The scant focus on time accords with broader organizational scholarship, that has moved away from

historical studies in the 1950s in an effort to emulate natural science methodologies, only to rekindle its interest in a historical perspective in more recent years (Kipping & Usdiken, 2014).

This lacuna is unfortunate since organizational ambidexterity, as the ability to both exploit and explore, involves a dynamic aspect of the need to deal with context-bound, messy organizational issues, over substantial time periods (Raisch et al., 2009). The contextual richness and particular organizational nuances that develop over time and that can inform our understanding of why some organizations accomplish ambidexterity while others struggle to do so can best be picked up via historical - contextual approaches. As O'Reilly and Tushman (2013: 330) highlight, "it may be that time is a crucial contingent variable." In our study, we explore how an organization's historical trajectory can shape the present, and in particular its ability to accomplish ambidexterity.

THEORETICAL BACKGROUND

Organizational Ambidexterity Research

Organizational ambidexterity as a term was first employed by Duncan (1976), who proposed the creation of dual structures to facilitate different phases of the innovation process; explorative structures for the initiation stage and exploitative ones for the latter implementation stage. It was not until March's (1991) seminal paper however that the notion of ambidexterity achieved traction in the management literature. March (1991) identified exploration with activities of "search, variation, risk taking, experimentation, play, flexibility, discovery, innovation"; and exploitation with "refinement, choice, production, efficiency, selection, implementation, execution" (March, 1991: 71). March noted that even though these two types of activities are in tension as they compete for scarce resources and involve different types of activities, both should nevertheless be pursued. The attempt to do both however runs the risk of

the “failure trap”, a focus on exploration at the expense of exploitation; and the “success trap”, a focus on exploitation at the expense of exploration (Levinthal & March, 1993). These authors advocated organizational learning and adaptation as a means of overcoming the inertia occasioned by path dependency.

As a way of accomplishing ambidexterity, O’Reilly and Tushman (1996) and Tushman and O’Reilly (2004) recommend structural separation, the creation of separate units to pursue exploration, as other units focus on exploitation, all within the corporate umbrella; where coordination of the two types of units is carried out by the top management team. A second prescription for achieving ambidexterity is temporal separation, where business units focus on either exploitation or exploration at different time periods; typically through long spells of exploitation punctuated by shorter periods of exploration (Romanelli & Tushman, 1994; Siggelkow & Levinthal, 2003). Finally, Gibson and Birkinshaw (2004) and Birkinshaw and Gibson (2004) identify contextual ambidexterity, where organizations develop a supportive but stretching context that encourages the pursuit of both exploitative and exploratory activities by actors depending on the contingencies they face in their task environment.

Related research has expanded the agenda beyond the organizational level (Stadler, Rajwani & Karaba, 2014) and proposed that inter-organizational relationships (Im & Rai, 2008; Kauppila, 2010), network structures (Riccaboni and Moliterni, 2009) and differentiated intra-company ties in the context of strategic alliances (Tiwana, 2008) can be ways of gaining particular competencies that can help balance exploration and exploitation (Turner, Swart & Maylor, 2013).

Empirical studies of ambidexterity largely focus on environmental, organizational, and senior management team antecedents, as well as the tradeoffs involved such as short vs long term or stability vs adaptability (Lavie, Stettner & Tushman, 2010), with the research finding broadly

positive relationships between particular dimensions of ambidexterity and organizational performance (Junni et al., 2013).

The Paucity of Time and Context

The shaping role of history is recognized in the ambidexterity literature. As Lavie et al. (2010: 121) note, the differences across organizations' tendencies to exploit or explore are related to particular organizational features such as structure and culture, that are in turn rooted in the organization's particular history. Yet, empirical studies have not adequately examined how history can shape an organization's propensity to be ambidextrous. Existing research potentially neglects important historical and contextual elements relating to both internal and external interdependencies that can facilitate or impede ambidexterity. As Raisch et al. (2009) note, the dynamic dimension of organizational ambidexterity is not well understood. Simsek et al. (2009: 888) further observe that "extant research on ambidexterity has been mostly cross-sectional while longitudinal studies are needed to observe the processes underlying ambidexterity types within an organization". Finally, Raisch and Birkinshaw (2008: 402) call for longitudinal, process-oriented research that entails "a methodological shift … to overcome the present research's static character".

A historical, contextual perspective offers a useful means of understanding an organization's present, and in particular its ongoing propensity to accomplish ambidexterity. We examine how organizational and environmental features can foster as well as frustrate efforts towards ambidexterity over time. Dominant prescriptions for accomplishing ambidexterity (structural, temporal or contextual ambidexterity) are useful as broad approaches, but cannot offer detailed understanding of why an organization has or has not managed to accomplish ambidexterity. Further, they cannot be implemented in a vacuum since historical and institutional factors shape the feasibility of such broad-level prescriptions.

METHODOLOGY

Our research question therefore is: how do an organization's history and context shape its ongoing propensity to be ambidextrous? In order to address this question, we conducted a longitudinal, holistic case study of NASA (Eisenhardt, 1989; Yin, 2008). NASA has had to deal with ambidexterity pressures as its institutional environment shifted, available resources declined, and a "business ideology" became more important to its continued legitimacy (Vaughan, 1996: 210). We employ NASA as an in-depth, longitudinal case study to trace how its historical development, its context, and key events have shaped its ongoing propensity to be ambidextrous. We draw from a variety of data sources which include committee reports, official statistics, organizational performance reviews, published research in space-related outlets that focuses on NASA, and books about NASA's history and particular programs. As such, we continue the tradition of conducting exploratory case studies as the main methodology of historical research; but in our case also accompanied by the aim of developing more generalizable theoretical insights, as recommended by de Jong, Higgins and van Driel (2015).

Our narrative extends from 1958 when NASA was founded as a legal entity, until the present. Kipping and Usdiken (2014) distinguish between two interrelated approaches of engaging with organizational history; "history *to* theory", where historical evidence is employed to inform theory-building, and "history *as* theory", where history enters theory as an influencing and explanatory variable in its own right. "Historical cognizance" refers to studies that take history seriously and employ elements from both these approaches. In this study we investigate how NASA's historical trajectory shapes its present, particularly its propensity to accomplish ambidexterity, and derive certain theoretical insights, a "history to theory" approach. However we also derive historical processes such as imprinting (Marquis & Tilcsik, 2013) and path

dependence (Sydow, Schreyogg & Koch, 2009) as explanatory factors, a "history in theory" approach.

We selected NASA as our research case via theoretical sampling (Eisenhardt & Graebner, 2007) since the organization presents a unique setting with respect to the pressures it faces for balancing exploration and exploitation; and its efforts over time to do so, that have been shaped by its history (Bruggeman, 2002). NASA's mission is space exploration, which requires outstanding organizational capabilities in terms of innovation of technologies and processes, often to address technical challenges that have not been met before (such as the effects of space on various aspects of human physiology over time and how to control these). NASA also strives to execute missions safely, with high reliability and minimal error, as a high reliability organization (Boin & Schulman, 2008). Consistent with broader trends on new public management (Reay & Hinings, 2009), over time government agencies have been required to do more with less, raising the efficiency demands on NASA. The emergence of external competition from private space companies and other states with space capabilities mean that NASA is not the only game in town any more. To deal with the simultaneous, twin demands of exploration and exploitation (March, 1991), NASA has been working towards becoming more ambidextrous (Core Magazine, 2016; Gonzalez, 2010) through initiatives such as open innovation (Lakhani, Lifshitz-Assaf & Tushman, 2013) and expanded partnerships with the commercial sector accompanied by related organizational changes to facilitate these collaborations (Ochoa, 2012).

The unit of analysis is NASA within its context (Yin, 2008). The longitudinal aspect of the data allowed us to gain a deeper understanding of how contextual dimensions can facilitate or create barriers to organizational ambidexterity over time. We conducted our analysis using the procedures of grounded theory (Corbin & Strauss, 2008), which have enabled us to identify initial narrative themes in the data, which then cohered into second order themes, which

themselves clustered into aggregate categories. In this process, we drew from a variety of data sources, engaging in data triangulation (Jick, 1979) in order to enhance the internal validity (Gibbert, Ruigrok & Wicki, 2008) of the analysis. We engaged in pattern-matching of data from various sources, as well as between data and theory (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). Figure 1 below portrays the themes that arose from the analysis; and Table 1 provides representative fragments of data that comprise these themes.

Figure 1 about here

Table 1 about here

NASA'S HISTORICAL TRAJECTORY AND THE PURSUIT OF AMBIDEXTERITY

NASA's Creation Through a Federation of Pre-Existing Research Labs

NASA was instituted by the US Congress as a legal entity in 1958 with the mandate of accomplishing "the preservation of the role of the United States as a leader in aeronautical and space science and technology" (National Aeronautics Space Act, 1958, Sec102, c5). NASA was initially primarily constituted by pre-existing laboratory operations of the research centers of the National Advisory Committee for Aeronautics (NACA), which has been created in 1915 to help expedite the development of US aeronautical technology after the onset of the First World War (NASA History Program Office). On 1st October 1958, five NACA facilities officially constituted NASA: the Lewis Research Center (Ohio), the Langley Research Center and Wallops rocket test range (Virginia), and the Ames Research Center and Muroc aircraft test range (California). At its founding NASA had 8,240 staff, 8,000 of which came from NACA, and an annual budget of US$

100m (Portee, 1998). NACA's culture emphasized a can-do, problem-solving attitude, applied experimentation in well-run laboratories with a focus on aeronautics, and work with contractors as needed, to supply required infrastructure such as parts of large wind tunnels or other simulators (Bugos & Boyd, 2008).

In July 1960 the Army Ballistic Missile Agency in Alabama, which included German rocket scientists who moved to the US after the Second World War, formally became a part of NASA and was renamed the George C Marshall Space Flight Center. In May 1961 President Kennedy announced the objective of "landing a man on the moon and returning him safely to earth" before the decade was out. Later that year, in September, newly appointed NASA Administrator James Webb announced that the Manned Spacecraft Center in Houston (renamed as the Lyndon B Johnson Space Center in 1973), which grew out of the Space Task Group of the Langley Research Center, would be the NASA center responsible for human space flight. The John F. Kennedy Space Center was then founded in 1962 in Florida, as a primary launch facility, managed by German Engineers from the Marshall Space Flight Center.

Each center developed a particular culture through its history. Employees of Langley laboratory for example took pride in Langley's intellectual prowess in terms of technology. The Ames laboratory was a spin-off of the Langley laboratory and displayed a strong engineering hands-on approach. The rocket scientists at the Army Ballistic Missile Agency embodied a highly technocratic culture with particular emphasis on detail, proceeding incrementally and being in control of all stages of a project from technical research and planning to actual fabrication of equipment. In contrast to the in-house culture at Langley Center and the ABMA (later Marshall Center), the Manned Spacecraft Center (later Johnson Space Center) relied to a larger extent on contractors' assistance for a significant part of its activities (McCurdy, 1993, 2010). Each center was dedicated to exploration in its own domain, within a largely decentralized corporate design.

Reliance on technical competencies that were found within the organization was a founding principle. The centers had a robust sense of autonomy, engendering a "not invented here" attitude and a sense of technical superiority that was part of the political narrative at the time. At the time, accomplishing technological breakthroughs that would aid space exploration and achieving the geopolitical goals of the US was instrumental, downplaying the need to do so efficiently. In this sense the ambidexterity pendulum was swung in the direction of exploration and away from exploitation.

Spatial Separation and Ambidexterity at the Founding of NASA. According to Levine (1992: 199), "From its very inception, NASA was not a unified whole … Glennan, the first NASA administrator, saw as one of his main tasks the integration of these diverse units into one organization. But that integration never took place", leading to overlap of responsibilities and poor coordination. Structural and spatial separation has been suggested as an organizational way to accomplish ambidexterity, where explorative units are separated from exploitative units, and coordination takes place by senior leadership (O'Reilly & Tushman, 1996; Tushman & O'Reilly, 2004). The objective is to enable exploration to take place unencumbered by established corporate constraints, and for the results of exploration to be subsequently efficiently exploited by related subunits. Despite the challenges of low cross-center integration, spatial separation at NASA was an early form of ambidexterity.

NASA had to still fulfill the core function of aeronautics research that was its NACA legacy while embarking on the human exploration of space. Langley, Ames and Lewis were Centers dedicated to ongoing aeronautics research, providing services and knowledge to the aeronautics industry; while the newer centers were focused on exploration of space. The Centers' different histories, cultures, spatial separation across the country, decentralization and high degrees of autonomy facilitated the agency's ability to simultaneously exploit the existing

resources and infrastructure to support the growing aeronautics industry while taking the risks required to achieve the goal of landing a man on the moon by the end of the decade. The loose coupling across the Centers enabled organizational adaptability as the demands of the environment and mission imperatives changed. NASA maintained its spatial separation for future exploration missions when it added the Goddard Research Center and Jet Propulsion Laboratory. This organizational differentiation served NASA well during its creation. However, separation would become a challenge as the agency shifted priorities and resources more towards exploration projects and less on exploitative projects; loose coupling involved some duplication of resources and research efforts, which challenged efficiency.

Shared Norms and Super-Ordinate Goal Lead to Outperformance in the 1960s

Despite the spatial separation and differences in culture across the Centers, there were from the early years several common norms which derived from their laboratory, applied research-oriented history, as well as the professional cultures of scientists and engineers: "a commitment to research, testing and verification; to in-house technical capability; to hands-on activity; to the acceptance of risk and failure; to open communications; to a belief that NASA was staffed with exceptional people; to attention to detail; and to a 'frontiers of flight' mentality" (McCurdy, 1989: 302).

The precipitating event triggering higher degrees of cooperation among the dispersed units was the shared desire "to go to the moon, plus the competition and the deadline that was imposed by the knowledge that the Russians were trying to do the same … When project Apollo came along in 1961, it transformed the requirements that were placed on these research laboratories" (McCurdy, 2013). President Kennedy's September 1962 speech instilling to the nation the vision of going to the moon and returning safely before the decade was out, was a super-ordinate goal that precipitated a period of intense focus and collaboration at NASA, what

Tushman and O'Reilly (1996) refer to as a revolutionary change. The shared vision of going to the moon and returning safely was a strong integrative force (Jansen et al., 2008) that highlighted common norms and helped to integrate the de-centralized and autonomous units.

In the early years NASA was able to develop and maintain its technical capability by practicing and prioritizing in-house technical work and a hands-on work environment for its engineers which had originated with NACA and AMBA. Hands-on work helped to maintain in-house technical capabilities, a pride in NASA's own competencies, the ability to keep engineers up to date and the potential to attract exceptional employees (McCurdy, 2010). The emphasis on extensively testing hardware before sending it into space was an important operating principle of each of the centers, a shared value that became stronger when human space flight begun. This also shaped the relationship with contractors in terms of "contractor penetration" by NASA personnel to ensure that these norms were adopted (McCurdy, 1993: 117).

In terms of Sheremata's (2000) insights about the need to balance centrifugal and centripedal forces, NASA's culture from its founding was primarily centrifugal, without a robust institutionalized element of centripetal forces to counterbalance the centrifugal element. The super-ordinate goal of putting a man on the moon combined with the cold war competitive context, acted as robust centripetal forces during the 1960s, facilitating NASA's first human moon landing in 1969. Following the Apollo program, the agency instituted centripetal forces through creation of program offices that integrated information from various centers to support collective action in pursuit of the program goals. Program offices acted as centripetal forces to balance the centrifugal tendencies of the centers. However, the effects of centrefugal forces have persisted. According to the Space Foundation (2012: 17) report, "while the centers can and do cooperate on specific matters, anything that challenges a center's autonomy, independence, or turf is met with immediate and stubborn resistance".

Creeping Regulation and Inertia Revector Both Exploration and Exploitation

After its founding in 1958 and during the Apollo era (1961-1972), NASA enjoyed a great degree of autonomy in setting its own processes, for example in terms of recruitment and remuneration. NASA enjoyed a reputation as a high-end, frontier-pushing scientific organization, thereby being able to attract young employees from top tier universities. The average age of employees in the control room during the moon landing in 1969 was 26 (Teitel, 2012). Under NASA's first Administrator, Keith Glennan (who led NASA from October 1958 to January 1961) Congress had allowed NASA to fill over 700 positions that were not subject to federal pay scales, affording the organization flexibility to compete with industry for the brightest, most capable employees (Levine, 1982).

The Ethics in Government Act of 1978, introduced after the Watergate scandal, had the noble intent of creating more transparency and limiting lobbying power. Public officials had to disclose financial and employment history, and public agencies were hampered in their ability to employ people who have worked in industry due to possible conflicts of interest. The Federal Civil Service Agency reversed NASA's rights to pay salaries to specialists that were not subject to Federal Payment Regulation thereby limiting NASA's flexibility in comparison to industry (Levine, 1982).

Employee turnover rates at NASA reduced and new hires decreased, leading to a steadily aging demographic within the agency. Between 1960-1968, turnover rates ranged between 10-15%, whereas between 1969-1990 they ranged between 5-10% (McCurdy, 1993). Over the last two decades employee turnover rates have been on a downward trend, with the turnover of non-retiree employees falling to 1.7% in 2013. Further, the average age of NASA employees has been on the rise. In 1993, 45-59 year-old employees made up 38% of NASA's workforce; by 2013 this figure was 57%. In 1993, 20-34 year-old employees made 32% of NASA's workforce. By 2013,

this figure decreased to 15%. NASA is not immune to the workforce challenges that face other industries with an experienced technical workforce that remain in the company due to emotional attachment to the mission. The challenge resides in the infusion of new perspectives, ideas and business processes that can challenge the organizational routines and shared norms that can become more established and inflexible over time. NASA has over time sought to restructure itself and initiate partnerships with the commercial sector to infuse new perspectives into the organization.

Meanwhile, more structured management approaches were implemented. Given the administrative requirements of the Apollo program, the government ushered in large systems engineering principles imported from the military. These were authorized by headquarters (level A) and employed by program offices (level B) to coordinate projects across subunits (level C). Hierarchy and formalization, inspired by military roots, increased. Progressive budget restrictions following Apollo led NASA to expand contracting out to organizations that could perform tasks or develop technology more efficiently, and less hands-on work was conducted internally (McCurdy, 1989). This shift towards private industry also provided seed capabilities to grow the commercial space community. As more expertise was distributed to the contractor community it provided more opportunity for new aerospace companies to emerge and leverage this engineering input.

Concurrently general federal regulations grew, imposing higher administrative demands on NASA in terms of the introduction of expanded accounting standards, occupational health and safety and environmental protection laws, and over 60 new procurement laws between 1965 and 1991. US Congress staff grew 300% in the first 30 years of NASA's existence, which increased the demands on government agencies in their efforts to engage with US Congress (McCurdy,

1993). Tragic accidents such as the fire on board of Apollo 1 in 1967 and the Challenger disaster in 1986 heavily increased political oversight.

NASA was not immune to the growth of state administrative regulations and need for detailed reporting led to corresponding growth in all of the government agencies and NASA's own dedicated administrative resource. Up till 1956, around 2% of NASA's employees were working in the agency's headquarters. By 1990, this figure had risen to almost 9%. Further, while around 5% of NASA employees were professional administrators in 1961 working in all of NASA's units, this figure had risen to over 18% by 1991 (McCurdy, 1993).

Process management tools such as ISO and Six Sigma have been implemented at NASA. Benner & Tushman (2003) note that the standardization and efficiency orientation of such tools have a variation decreasing effect; they streamline processes but at the same increase inertia and decrease adaptability. Researchers have associated inertia with a company's age and size, higher levels of which tend to foster bureaucracy (Han et al., 2001) unless there is a strong market orientated culture to act as an effective countervailing force. Tushman and O'Reilly (1996: 18) associate firms that have grown in size and age with structural and cultural inertia, the "organizational equivalent of high cholesterol". The burgeoning of regulatory demands on NASA, and the corresponding internal increase in administrative resource, coupled with lower flexibility in terms of human resource decisions and a low turnover in the workforce, were factors that together contributed to an increase in structural and cultural inertia at NASA. These factors created potent challenges to ambidexterity. Concurrently, despite these factors, NASA was still able to accomplish exploration missions that included the Mars Pathfinder, Hubble Space Telescope, Space Shuttle, Shuttle-Mir Program and the International Space Station.

FBC Approach Aims to Accomplish Ambidexterity But Has Mixed Record

Responding to stakeholder concerns about NASA's high costs, Daniel Goldin, NASA administrator from 1992 to 2001, introduced the "faster, better, cheaper" (FBC) approach which aimed to continue bold exploration but at significantly lower cost (Lambright, 2007); in other words, aiming to simultaneously accomplish both exploration and exploitation. Historically, NASA processes have been influenced by the systems management approach brought in from the Air Force during the Apollo era. Systems management combined both decentralization, leaving individual centers the freedom to carry out technical hands-on activity and extensive testing, with centralization through the employment of highly detailed procedures by central project managers to track the progress of large projects with the ultimate aim of tracking performance and reliability (McCurdy, 2001). The focus on testing and reliability reduced the likelihood of failure, but at the same time downplayed cost awareness. In order to achieve maximum reliability, and influenced by NASA's technocratic culture, engineers incorporated redundancy for multiple scenarios, tested parts relentlessly and built in various sensors and safety features, resulting in skyrocketing costs and stretching of schedules (McCurdy, 2001).

Goldin's FBC approach involved focus on smaller missions, incorporation of advanced technology, reduction of headquarter management and decentralization to centers, a higher emphasis on teamwork and co-location, and lower emphasis on detailed documentation. Nevertheless, FBC programs met as a whole met with a 37% failure rate, significantly above previous norms. There were two main reasons for these higher failure rates. First, linear increases in project complexity entailed exponential increases of required project costs to effectively address this complexity (Bearden, 2003; Sarsfield, 1998). FBC however involved cost and schedule reduction at a faster rate than that which complexity could be reduced, leading to higher failure rates. Second, there was incongruence between the FBC way of doing things and the established large systems management approach. This large systems approach involved hands-on

extensive testing and documentation and continued significant outsourcing to contractors who were not entirely on board with the FBC approach. The inertia of existing processes led to inadequate coordination between different teams and centers involved in projects (McCurdy, 2001). For example, for the Climate Orbiter project carried out under the FBC approach, the Jet Propulsion Laboratory cooperated with the private corporation Lockheed Martin Astronautics. The project, which aimed to launch a probe to Mars, failed due to the fact that JPL used the metric system for their calculations whereas Lockheed Martin used English imperial measurements. The Climate Orbiter cost $326.6m to develop and simply disappeared behind Mars (NASA, 2013). It would be fair to say that the FBC approach left a mixed legacy within NASA (Lambright, 2007; McCurdy, 2013) and despite its best intentions it was not successful in accomplishing ambidexterity.

Funding Uncertainty and Temporal Incongruence Both Impede and Foster Ambidexterity

NASA's budget accounted for 4.5% of the federal budget in 1969, the year of the moon landing, having risen steeply to that percentage from a base of around 0.1% in 1958, the year of NASA's founding. The dramatic rise in funding in NASA's initial years had a significant impact on NASA's cultural attitude towards efficiency (exploitation). The goal of human spaceflight in the 1960s was primarily geopolitical (National Research Council, 2012). Given the Cold War context that triggered the space race, the belief developed within NASA that the US government would spend any amount needed to establish US leadership in space. Accomplishing the goals mattered much more than doing so efficiently (Hall, 2003; McCurdy, 2001). After the manned moon landings (1969-1972), many politicians were not convinced about the need to continue spending large amounts on spaceflight, which led to gradual reductions in NASA's budget (McCurdy, 2001). By 2013 NASA's share of the federal budget had progressively dropped to 0.5% while the number of programs it was required to support increased.

In order to receive funding for large projects, project managers often indicated overly optimistic cost projections when applying for funding (National Research Council, 2012). Year after year NASA received cuts to its budget necessitating it to re-plan programs and reduce capabilities from the original design, that resulted in impacting the total life cycle cost. For example, individual launch costs of the space shuttle were estimated at $450 million but then cost $1.3 billion per flight (Pinchefsky, 2012). Even with these changes the shuttle vehicles flew 135 missions and carried the components to create the International Space Station.

Over the years, there has been some ambivalence in how stakeholders view NASA. According to a 1961 Gallup poll, 52% of Americans believed that NASA would reach the moon until the decade was over, but 58% felt that Congress was spending too much money for this endeavor (McCurdy, 2001). A Gallup poll in 2009 indicated that 58% of polled individuals agreed that NASA had created enough benefits for the US and is worth its costs, 13% believed that NASA was doing an excellent job, and 45% it was doing a good job (Gallup, 2009). When the National Research Council conducted an independent assessment of NASA's strategic direction and agency management, it reported that NASA's strategic planning process was influenced to a greater extent by outside forces than internally (National Research Council, 2012), consistent with the fact that NASA's funding derives externally. NASA programs and direction are influenced by its stakeholders: the public, congress, and the president.

NASA is expected to accurately forecast, for projects that take years or decades to develop, how much cost it will occur in a specific year. Yet, the appropriation of funds by Congress occurs on an annual basis. Hence, there is a temporal incongruence between NASA's program development and US Congress funding mechanisms. McCurdy argues that this "encourages bureaucrats to spend money they do not need or waste time waiting for appropriations they have not received" (McCurdy, 2001: 96) and may lead to "maintaining

people on the payroll without giving them the money to build something" (McCurdy, 2013). The annual budget-driven approach often results in NASA having to stretch project schedules to accommodate the changes and the re-planning that increases fixed and indirect costs (National Research Council, 2012). Further, the out-year budget projection provided to NASA has been characterized as unreliable, creating difficulties for program managers to plan on a multi-year basis (National Research Council, 2012).

The ability to be adaptable is essential due to the tenure of the President of the United States being four years and the tenure of US Congress officials being two years (House of Representatives) or six years (Senate). Political (and thus financial) support of space endeavor might shift with a new President. A prime example of political uncertainty was exemplified by the cancellation of the Constellation program, initiated in 2004, by President Obama in 2011. The Constellation program was intended to support NASA's capabilities for human space flight to return to the moon, and a future orientation towards reaching out to Mars. As part of the initial strategy, President Bush initiated the completion of the shuttle program and the seeding of a commercial space market to allow NASA to gain access to the International Space Station (ISS) on a commercial vehicle. Constellation also provided a replacement capability for the shuttle program to go to ISS and to grow that capability to explore beyond Earth. However, the funding required for full constellation execution was never provided (Augustine et al., 2009). Faced with a decision of increasing the budget to fund constellation fully or canceling the program and scoping a new program to fit within a constrained budget, President Obama cancelled the program. His budget increased funding for growing commercial industry to provide spaceflight to and from the ISS, and removed the NASA vehicle that had been planned to do so. However, Congress strongly advocated that NASA should develop its own competencies in crew transportation systems. In 2010, US Congress and President Obama agreed on a compromise that

over-stretched NASA's resources: NASA was to develop a new space launch system, evidently replacing the cancelled Constellation program, and simultaneously fund and exploit the new commercial crew transportation market (National Research Council, 2012).

The inefficiencies engendered by funding uncertainty and temporal incongruence compromise the pursuit of ambidexterity since operational priorities can change unexpectedly; this occurs directly through practices such as project stretching, and indirectly through the long-term effects of uncertainty on the organization culture of NASA. However, uncertainty can also heighten the need to be ambidextrous since ambidextrous organizations are also adaptable to change and able to function more effectively under conditions of uncertainty.

External Critiques of NASA and Shifting Competitive Environment

Reports of independent inquiries after both the Challenger and the Columbia disasters were critical of several organizational aspects of NASA, including its risk management and safety processes. More recent reports continue to be critical. The National Research Council (2012) report for example found that there is no national consensus on NASA's strategic goals and objectives, without which NASA cannot be expected to have a clear long-term plan and implement it effectively. NASA's strategic plan was described as vague, lacking prioritization and clarity, and its vision and mission statements were described as generic rather than unique. Secondly, the report contended that there is not sufficient integration across the different NASA field centers which compromises the accomplishment of agency-wide goals and objectives. Thirdly, that significant constraints imposed by legislation and regulation, such as rules regarding variations in workforce and uses of infrastructure impede NASA's flexibility in accomplishing its goals. Fourth, that there is a significant mismatch between the programs NASA has set out to carry out, and the budget available.

Published in the same year, the Space Foundation (2012: 1) report noted that there are "frequent redirection and constantly shifting priorities at NASA, mixed signals from Congress and the administration, organizational conflicts, and the lack of a singular purpose, resulting in a space agency without a clear, stable direction". The report made several strategic and tactical recommendations, including the development of a clear purpose for NASA, more stable funding and the appointment of NASA administrators with a fixed term of 5 years which would be unaffected by changes in presidency and "arbitrary changes in the direction of the agency" (2012: 2) that a new administration can bring.

Meanwhile, both the private sector and other nations have been investing in and developing space technologies, challenging NASA's historical dominance of and leadership in space exploration. Private space companies such as Space X and Blue Origin, even though they often license NASA technology, compete for NASA contracts and employ NASA scientists, can also undertake certain tasks (such as transporting cargo to the International Space Station) more efficiently than NASA and have commendable innovation goals. Hyper-ambitious and well-funded national space agencies such as China National Space Administration mean that NASA has real competition on space-faring competence. According to the Space Foundation (2014), global spending on space-related activities was US$314bn, and with NASA's budget of US$18bn, it accounted for 5.7% of this spending.

NASA has more recently started experimenting with open innovation, posing innovation challenges online in open competitions, as a complement to internal innovation efforts. The possibility for task decomposition and the wide problem-solving capabilities (Lakhani, Lifshitz-Assaf & Tushman, 2013) make this a potentially effective exploration approach, at lower cost. However open innovation can address only a particular part of NASA's total technological and operational challenges, making it a useful but not sufficient approach to innovation.

DISCUSSION

The Historical and Contextual Embeddedness of Organizational Ambidexterity

Viewing an organization in a historical - contextual manner highlights how its experiences and the way particular organizational features develop can have complex, systemic effects on its propensity to accomplish ambidexterity, in a way that results in unique organizational configurations. In particular, our analysis of NASA's historical trajectory has pointed towards a number of key themes that cohered in terms of two broad categories; organizational features and the role of the external environment, both of which shape NASA's ongoing propensity to accomplish ambidexterity.

Figure 2 about here

The causality of the factors identified in Figure 2 with respect to organizational ambidexterity however is hard to discern and could at times be dual, both supporting and impeding ambidexterity. Structural separation at NASA for example has had both positive and negative effects. The separation of exploitative and exploratory units aided ambidexterity in the sense that it enabled the organization to innovate (explore) as well as implement (exploit) effectively, by focusing each Center on its area of competence. The decentralization and low cross-unit integration however led to duplication of activities and compromised efficiency. Table 2 below offers an outline of key themes, their effects on propensity to be ambidextrous, and the organizational rationale for this evaluation.

Table 2 about here

Table 2 shows that a variety of environmental and organizational factors can have plural and often unexpected effects on an organization's propensity to be ambidextrous. Contrary to broad prescriptions for accomplishing ambidexterity, our findings point towards a particularist perspective on ambidexterity as a historically and contextually embedded process.

This finding can shed light on why in ambidextrous organizations it may be challenging to characterize their implementation modes along any of the dominant prescriptions of ambidexterity. Adler, Goldoftas and Levine's (1999) study of Toyota revealed for example that the manufacturing operations of the company can accomplish both efficiency as well as flexibility via four processes: metaroutines, enrichment, switching, and partitioning. However, it is difficult to juxtapose these organizational practices with the dominant ambidexterity prescriptions. It is worth noting that Toyota's lean manufacturing system has as yet not been successfully imitated by other auto-makers, and the unique Japanese heritage of Toyota is a significant part of the explanation of why this is so.

Ambidexterity as a Path-Dependent Process

Our case analysis shows how propensity to be ambidextrous is shaped by prior organizational trajectories and external conditions. Sydow, Schreyogg and Koch (2009) view path dependence as a pattern of actions that arises from the "unintended consequences of former decisions and positive feedback processes" (p. 696), ultimately leading to lock-in that is hard to escape from. Combined with organizational decentralization and relatively low levels of cross-center integration, NASA's formative period set the scene for substantial path-dependent constraints on accomplishing ambidexterity, in a process that has been referred to as "imprinting" (Marquis & Tilcsik, 2013). Imprinting is defined as "a process whereby, during a brief period of susceptibility, a focal entity develops characteristics that reflect prominent features of the

environment, and these characteristics continue to persist despite significant environmental changes in subsequent periods" (p. 201).

NASA was created to fulfill geopolitical goals with ample funding from the state, so that it could single-mindedly pursue the moon-landing goal posed by President Kennedy, within a clearly defined timeframe. Reliability and safety were key features of the organizational culture, and cost consciousness was not top of the agenda. Since organization culture is shaped by early experiences, successes and challenges of a group (Schein, 1990), NASA continued its path, till the present, with a hardwired norm that efficiency was not key.

Subsequent efforts such as the FBC (Faster, Better, Cheaper) approach aimed to accomplish exploration with as low cost as possible, presenting a direct challenge to the organization culture. This approach was prompted by tighter funding and the gradual injection of market discipline via private sector competition and competition from other nation states, that have acted as prompts to balance exploration and exploitation more effectively. FBC was an unprecedented experience for the organization that was met with mixed results, as the approach proved unsuitable for projects of high complexity.

Our study shows that context and history matter to the accomplishment of ambidexterity because they create particular trajectories of path dependence for organizations. Path dependence as the "tendency for organizations to take decisions based on, and have their present state defined by, their history" (Hall, 2003: 240) has potent effects as can be seen for example in terms of inertia to change at NASA over the years, which impeded organizational change even after substantial shocks delivered by the tragic accidents in its history (Donahue & Leary, 2012). Figure 3 below outlines our findings in terms of the path-dependent nature of organizational ambidexterity.

Figure 3 about here

Our analysis therefore shows that pursuing ambidexterity is not just a matter of initiating organizational change along the lines of dominant prescriptions. Rather, it is a complex endeavor that must take into account how current organizational configurations have evolved over long periods in response to environmental features, stakeholder demands and task requirements.

Organizational Ambidexterity in Public Sector Organizations

The public administration literature has flirted with the concept of ambidexterity but has not as yet engaged substantively with it. The term was used as early as 1956, when Lappegaard, discussing the tensions between staff and line noted that certain principles could be used both to promote or castigate a course of action: "it's amazing how ambidextrous a principle can be sometimes … they can be used both for offense and for defense, and correctly too" (Lappegaard, 1956: 183). Brown-John (1976: 153) then referred to government agencies with both judicial and administrative powers as ambidextrous.

Kelman, Sanders and Pandit (2015) suggested that senior government executives need to be ambidextrous in terms of being able to switch between different decision models depending on the type of decision to be made. Fossestol et al. (2015) noted that public sector organizations need to be ambidextrous when dealing with contradictory demands such as a new public management logic simultaneously with a traditional service provision logic (see also Reay & Hinings, 2009). Bryson, Crosby and Stone (2015) argued that different types of ambidexterity (structural and processual) would be useful in dealing with the tensions engendered in large, multi-level cross-sector collaborations. In this literature however, the concept was at best incidental to the main focus of the research. It is safe to say that so far the concept of

organizational ambidexterity has not been used in the public administration literature in any substantive way.

However, our study implies that importing the dominant prescriptions of ambidexterity to the public sector may be ill-advised. Temporal ambidexterity for example would be unsuitable for NASA, since this avenue requires long periods of exploitation punctuated with short periods of exploration (or long periods of evolution punctuated by shorter periods of revolution). Rather, field centers have to continually explore, and ideally do so efficiently, within an exploitative mindset. Further, a punctuated equilibrium (temporal ambidexterity) approach involving transformational change has historically not been part of NASA's DNA, given the cultural emphasis on reliability and safety, which requires conservatism and adhering to procedure. With respect to ecological ambidexterity, the rise of competition in the space-faring industry necessitates the development of inter-organizational networks and partnerships (Stadler et al., 2014) that can offer technology and capabilities towards supporting both exploration and exploitation (Kauppila, 2010) to achieve stretching goals more efficiently. However NASA's public-sector oriented organization culture may not be fully conducive to such collaborations.

Whereas broad ambidexterity prescriptions seem clear enough, their implementation in particular settings such as the public sector is fraught with complexity. Our findings are particularly relevant to public sector organizations, that are caught in a double bind. On the one hand, the logic of the market and business ideology (Reay & Hinings, 2009) are supplementing a service logic (Fosstestol et al., 2015) and influencing governments' thinking about the funding of public sector organizations. Public-private partnerships often surface such tensions (Bryson et al., 2015). On the other hand, public sector organizations are constrained by regulations, history and culture on the means they can employ to become more efficient while offering high quality services, or in ambidexterity terms, balance the simultaneous pressures for exploration and

exploitation. Extending the use of the ambidexterity concept in the public administration literature would be useful in terms of shedding light on how the tensions invoked by the simultaneous existence of different, often conflicting logics can be handled by public sector organizations.

Practice Implications

Public sector organizations face added complexity in the pursuit of ambidexterity, since some of the levers habitually available in the private sector may not be feasible to employ in the public sector. A key implication for practice is that the implementation of initiatives towards ambidexterity has to be sensitive to the organization's prior path and the task it has to accomplish. This involves a delicate balancing act; a type of ambidextrous leadership (Tushman, Smith & Binns, 2011). On the one hand there is a need to have deep knowledge and appreciation of context and history and their effects, but at the same time also being mindful of the risks of "going native", taking for granted the current organizational arrangements and therefore not challenging them.

Further, leaders can be aware of the dual nature of crises that can act as opportunities, and to be ready to capitalize on those opportunities. For example, in NASA's case, tighter funding and intensifying external competition, both by states and by the private sector, has been challenging for a public sector organization that has traditionally been a global leader in its sector. Such conditions however have also spurred re-thinking of how to compete, and fostered initiatives such as open innovation (Lakhani et al., 2013) and collaborations with industry, that that can over time be beneficial for the journey towards organizational ambidexterity. A further implication for leaders concerns persistence, patience and focus. In every case where organizational ambidexterity is accomplished (e.g. Heracleous, 2013; O'Reilly & Tushman, 2004), it is the result of a multi-year journey with ongoing challenges. Even in these cases,

ambidexterity is a capability that has to be continuously supported and negotiated, and may decline if neglected.

Limitations and future research

We have based our study on a single, in-depth qualitative case study. As is appropriate to such studies, we aim for generalization to theory rather than statistical generalization (Yin, 2008). Our research question was how history and context could shape an organization's propensity to become ambidextrous, and the insights gained in this respect, and presented in with reference to NASA (Figure 2 and Table 2), as well as in a more generalizable format (Figure 3) can inform research in a number of other organizations. We acknowledge the limitations however that stem from research in a single case study. It would be beneficial to carry out multiple-case research and investigate whether our findings hold across cases.

A further limitation stems from the use of published data. It would have been useful to be able to utilize primary data based on interviews and observation. This would have allowed more extensive data triangulation as well as enrichment of certain themes. However, utilizing such data did not prove possible in this instance. It would be useful for further research to utilize first-hand accounts and triangulate them with published information.

Finally, we carried out this study from the perspective of pluralist organization theory rather than alternative perspectives such as systems theory or critical theory. No doubt alternative perspectives would uncover themes that we did not emphasize in this study. Further research could therefore investigate how public sector organizations deal with conflicting logics and tensions from a variety of perspectives so that a more rounded understanding can emerge.

REFERENCES

Abell, D. F. 1999. Competing today while preparing for tomorrow. *Sloan Management Review*, Spring: 73-81.

Adler, P. S., Goldoftas, B. & Levine, D. I. 1999. Flexibility versus efficiency? A case study of model changeovers in the Toyota production system, *Organization Science*, 10: 43-68.

Augustine, N. R., Austin, Bejmuk, B. I., Chiao, L., W. M., Chyba, C., Crawley, E. F., Greason, J. K., Kennel, C. F., Lyles, L. L., Ride, S. K. 2009. Seeking a human spaceflight program worthy of a great nation. Washington, D.C.

Bearden, D.A. 2003. A complexity-based risk assessment of low-cost planetary missions: when is a mission too fast and too cheap? *Acta Astronautica,* 52: 371–379.

Benner, M. J., Tushman, M. L. 2003. Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review,* 28: 238–256.

Birkinshaw, J., & Gibson, C. 2004. Building ambidexterity into an organization. *MIT Sloan Management Review*, *45*: 47-55.

Boin, A. & Schulman, P. 2008. Assessing NASA's safety culture: The limits and possibilities of high-reliability theory. *Public Administration Review*, Nov-Dec: 1050-1062.

Bruggeman, D. 2002. NASA: A path dependent organization. *Technology in Society*, 24: 415-431.

Bugos, G. E. & Boyd, J. W. 2008. Accelerating entrepreneurial space: The case for an NACA-style organization. *Space Policy*, 24: 140-147.

Cameron, K. 1986. Effectiveness as paradox: Consensus and conflict in conceptions of organizational effectiveness. *Management Science*, 32: 539-553.

Conley, R. S. & Cobb, W. W. 2012. Presidential vision or congressional derision? Explaining budgeting outcomes for NASA, 1958-2008. *Congress & the Presidency*, 39: 51-73.

Corbin, J. M. & Strauss, A. L. 2008. *Basics of qualitative research: Techniques and procedures for developing grounded theory*. CA: Sage.

Core Magazine. 2016. NASA's new space race, 1 September. Source: http://www.wbs.ac.uk/news/core-nasa-s-new-space-race/, accessed on 2 October 2016.

De Jong, A., Higgins, D. M. & van Driel, H. 2015. Towards a new business history? *Business History*, 57: 5-29.

Donahue, A. K. & O'Leary, R. 2012. Do shocks change organizations? The case of NASA. *Journal of Public Administration, Research and Theory*, 22: 395-425.

Duncan, R. 1976. T*he ambidextrous organization: designing dual structures for innovation*. In Killman, R. H., Pondy, L. R., & Sleven, D. (Eds.), *The management of organization design: Strategies and implementation*. North Holland, New York: 167–188.

Eisenhardt, K. M. 1989. Building theories from case study research. *Academy of Management Review*, 14: 532-550.

Eisenhardt, K. M. & Graebner, M. E. 2007. Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, 50: 25-32.

Gallup, 2009. Majority of Americans say space program costs justified. www.gallup.com/poll/121736/majority-americans-say-space- program-costs-justified.aspx, accessed 15 Feb 2015.

Garner, J. T., 2006. Masters of the universe? Resource dependency and interorganizational power relationships at NASA. *Journal of Applied Communication Research*, 34: 368-385.

Gibbert, M., Ruigrok, W. & Wicki, B. 2008. What passes as a rigorous case study? *Strategic Management Journal*, 29: 1465-1474.

Gibson, C. B. & Birkinshaw, J. 2004. The antecedents, consequences, and mediating role of organizational ambidexterity. *Academy of Management Journal,* 47: 209–226.

Gonzalez, S. 2010. Ambidextrous organizations: The power of AND. JSC Advanced Planning Office Blog, Source: https://blogs.nasa.gov/JSC_Advanced_Planning_Office_Blog/2010/03/28/post_1269804306882/, Accessed on 16 September 2015.

Hall, J. L. 2003. Columbia and Challenger: Organizational failure at NASA. *Space Policy*, 19: 239-247.

Han, J.K., Kim, N., & Kim, H. B. 2001. Entry barriers: A dull-, one-, or two-edged sword for incumbents? Unraveling the paradox from a contingency perspective. *Journal of Marketing,* 65: 1–14.

Heracleous, L. 2013. Quantum strategy at Apple Inc. *Organizational Dynamics*, 42: 92-99.

Im, G. & Rai, A. 2008. Knowledge sharing ambidexterity in long-term interorganizational relationships. *Management Science,* 54: 1281–1296.

Jansen, J. J. P., George, G., Van den Bosch, F. A. J., Volberda, H. W., 2008. Senior team attributes and organizational ambidexterity: The moderating role of transformational leadership. *Journal of Management Studies,* 45: 982–1007.

Jick, T. D. 1979. Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly*, 24: 602-611.

Johnson-Freese, J. & Handberg, R. 1991. Realigning NASA's destiny: The symbolic dimensions of spaceflight. *Technology in Society*, 13: 433-445.

Junni, P., Sarala, R. M., Taras, V., & Tarba, S. Y. 2013. Organizational ambidexterity and performance: A meta-analysis. *Academy of Management Perspectives*, 27: 299-312.

Kauppila, O-P. 2010. Creating ambidexterity by integrating and balancing structurally separate interorganizational partnerships. *Strategic Organization*, 8: 283-312.

Kipping, M. & Usdiken, B. 2014. History in organization and management theory: More than meets the eye. *Academy of Management Annals*, 8: 535-588.

Lakhani, K. R., Lifshitz-Assaf, H. & Tushman, M. L. 2013. Open innovation and organizational boundaries: Task decomposition, knowledge distribution and the locus of innovation. In Grandori, A. (Ed.) *Handbook of Economic Organization: Integrating Economic and Organization Theory*, Edward Elgar: 355-382.

Lambright, W. H. 2007. Leading change at NASA: The case of Dan Goldin. *Space Policy*, 23: 33-43.

Lavie, D., Stettner, U., & Tushman, M. L. 2010. Exploration and exploitation within and across organizations. *Academy of Management Annals*, 4(1): 109-155.

Levine, A. L. 1992. NASA's organizational structure: The price of decentralization. *Public Administration Review*, 52: 198-203.

Levine, A. S. 1982. Managing NASA in the Apollo era, http://history.nasa.gov/SP-4102/sp4102.htm, accessed 11 May 2014.

Levinthal, D.A., & March, J.G. 1993. The myopia of learning. *Strategic Management Journal,* 14: 95–112.

Lewis, M. W. 2000. Exploring paradox: Toward a more comprehensive guide. *Academy of Management Review*, 25: 760-777.

March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science,* 2: 71–87.

McCurdy, H. E. 1989. The decay of NASA's technical culture. *Space Policy*, 5: 301-310.

McCurdy, H. E. 1992. NASA's organizational culture. *Public Administration Review*, 52: 189-192.

McCurdy, H. E., 1993. *Inside NASA: high technology and organizational change in the U.S. space program*. Baltimore: Johns Hopkins University Press.

McCurdy, H. E., 2001. *Faster, better, cheaper: low-cost innovation in the U.S. space program*. Baltimore: Johns Hopkins University Press.

McCurdy, H. E. 2010. Inside NASA at 50. In Dick, S. J. (Ed.) NASA's first 50 years: Historical perspectives. NASA SP-2010-4704.

McCurdy, H. E. 2013. Learning from history: Low-cost project innovation in the U.S. National Aeronautics and Space Administration. *International Journal of Project Management*, 31: 705-711.

NASA History Program Office http://www.hq.nasa.gov/office/pao/History/SP-4406/chap1.html accessed 15 May 2015.

NASA, Workforce Information Cubes for NASA, https://wicn.nssc.nasa.gov/wicn_cubes.html, accessed on 15 May 2014.

NASA, 2013. Mars Climate Orbiter Fact Sheet. http://mars.jpl.nasa.gov/msp98/orbiter/fact.html, accessed 15 May 2015.

National Aeronautics and Space Act of 1958 (Unamended), http://www.hq.nasa.gov/office/pao/History/spaceact.html (accessed 15 Feb 2015).

National Research Council. 2012. *NASA's strategic direction and the need for a national consensus*. Washington DC: National Academies Press.

Ochoa, E. 2012. Presentation to NASA Advisory Council, Commercial Space Committee, May 1, Source: https://www.nasa.gov/sites/default/files/files/Ochoa_NACCommercialSpaceMay2012_508.pdf, Accessed on 16 September 2015.

O'Reilly, C. A., Tushman, M. L. 2013. Organizational ambidexterity: Past, present and future. *Academy of Management Perspectives*, 27: 324-338.

O'Reilly, C. A., Tushman, M. L. 2004. The ambidextrous organization. *Harvard Business Review,* 82: 74–81.

Papachroni, A., Heracleous, L. & Paroutis, S. 2015. Organizational ambidexterity through the lens of paradox theory: Building a novel research agenda. *Journal of Applied Behavioral Science*, 51: 71-93.

Pelton, J. N. 2006. Revitalizing NASA? A five-point plan. *Space Policy*, 22: 221-225.

Pinchefsky, C. 2012. 5 horrifying facts you didn't know about the space shuttle. http://www.forbes.com/sites/carolpinchefsky/2012/04/18/5-horrifying-facts-you-didnt-know-about-the-space-shuttle/, accessed on 15 Feb 2015.

Portee, D. S. F. 1998. NASA's origins and the dawn of the space age. Monograph 10, NASA History Division, http://history.nasa.gov/monograph10/, accessed 11 May 2015.

President's Commission on Implementation of United States Space Exploration Policy. 2004. *A journey to inspire, innovate, and discover*. Washington: U.S. Gov't Printing Office.

Raisch, S. & Birkinshaw, J. 2008. Organizational ambidexterity: Antecedents, outcomes and moderators. *Journal of Management*, 34: 375-409.

Raisch, S., Birkinshaw, J., Probst, G. & Tushman, M. L. 2009. Organizational ambidexterity: Balancing exploitation and exploration for sustained performance. *Organization Science*, 20: 685-695.

Reay, T. & Hinings, C. R. 2009. Managing the rivalry of competing institutional logics. *Organization Studies*, 30: 629-652.

Report of the Presidential Commission on the Space Shuttle Challenger Accident,1986, http://history.nasa.gov/rogersrep/genindex.htm, accessed 11 May 2014.

Riccaboni, M., & Moliterni, R. 2009. Managing technological transitions through R&D alliances. *R&D Management,* 39: 124–135.

Romanelli, E., & Tushman, M. L. 1994. Organizational transformation as punctuated equilibrium: An empirical test. *Academy of Management Journal,* 37: 1141–1666.

Sarsfield, L.1998. *The cosmos on a shoestring: Small spacecraft for space and earth science*. RAND, Critical Technologies Institute, Santa Monica, CA.

Schein, E. H. Organizational culture. *American Psychologist*, 45: 109-119.

Sheremata, W. A. 2000. Centrifugal and centripetal forces in radical new product development under time pressure. *Academy of Management Review,* 25: 389–408.

Siggelkow, N., & Levinthal, D. A. 2003. Temporarily divide to conquer: Centralized, decentralized, and reintegrated organizational approaches to exploration and adaptation. *Organization Science*, *14*: 650-669.

Simsek, Z., Heavey, C., Veiga, J. F., & Souder, D. 2009. A typology for aligning organizational ambidexterity's conceptualizations, antecedents, and outcomes. *Journal of Management Studies*, 46: 864-894.

Space Foundation. 2012. Pioneering: Sustaining US leadership in space. www.spacefoundation.org

Space Foundation. 2014. The Space report: The authoritative guide to global space activity. www.spacefoundation.org

Space Foundation. 2016. Ensuring U.S. leadership in space. www.spacefoundation.org

Spear, T. 1998. NASA FBC task final report. Jet Propulsion Laboratory. Retrieved from http://mars.jpl.nasa.gov/msp98/misc/fbctask.pdf

Stadler, C., Rajwani, T. & Karaba, F. 2014. Solutions to the exploration / exploitation dilemma: Networks as a new level of analysis. *International Journal of Management Reviews*, 16: 172-193.

Teitel, A. S. 2012. Apollo's youthful glow. http://amyshirateitel.com/2012/08/11/apollos-youthful-glow/, accessed on 15 Feb 2015.

Tiwana, A. 2008. Do bridging ties complement strong ties? An empirical examination of alliance ambidexterity. *Strategic Management Journal,* 29: 251–272.

Tompkins, P. K. 2005. *Apollo, Challenger, Columbia: The decline of the space program*. LA: Roxbury.

Turner, N., Swart, J. & Maylor, H. 2013. Mechanisms for managing ambidexterity: A review and research agenda. *International Journal of Management Reviews,* 15: 317–332.

Tushman, M. L., & O'Reilly, C. 1996. Ambidextrous organizations: Managing evolutionary and revolutionary change. *California Management Review,* 38: 8-30.

Tushman, M. L., Smith, W. K. & Binns, A. 2011. The ambidextrous CEO. *Harvard Business Review*, June: 74-80.

Vaughan, D. 1996. The Challenger launch decision. Chicago; University of Chicago press.

Yin, R. K. 2008. *Case study research: Design and methods*, 4th Edition. Applied Social Research Methods Series, Vol. 5. CA: Sage.

Figure 1

Initial Narrative Themes, Second Order Themes and Aggregate Categories

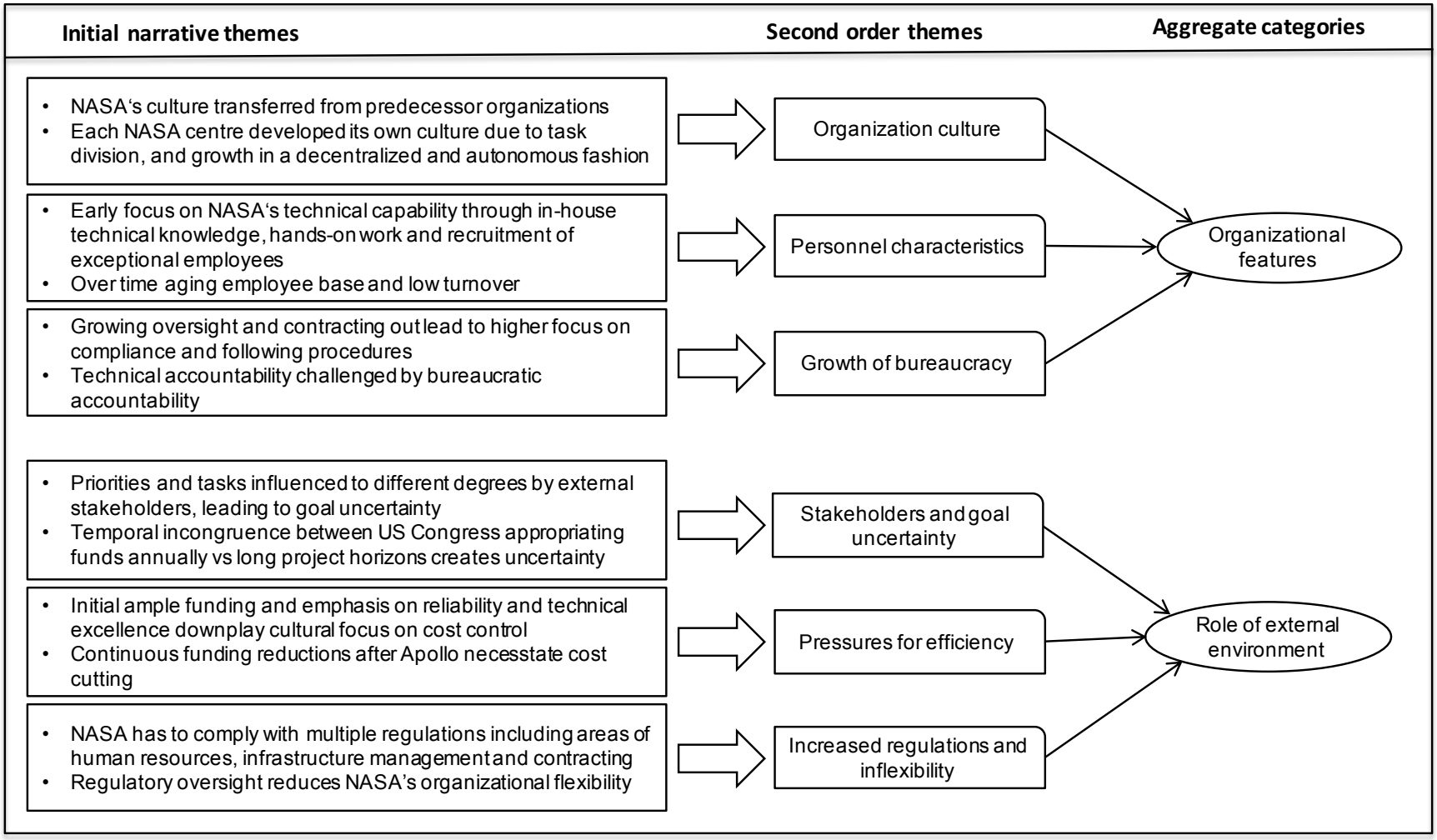

Figure 2

Environmental and Organizational Factors Shaping Ambidexterity at NASA

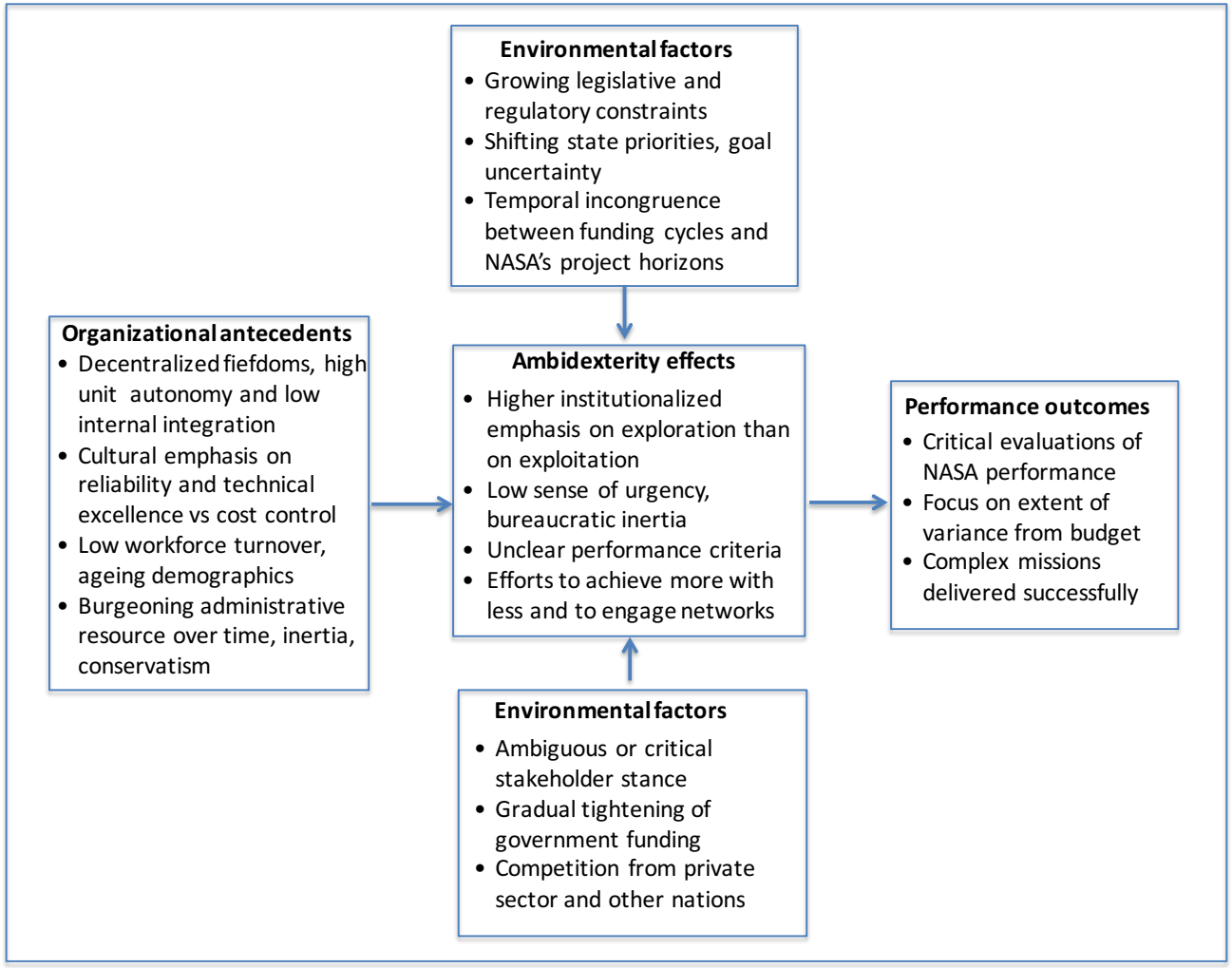

Figure 3

Path Dependence and Organizational Ambidexterity

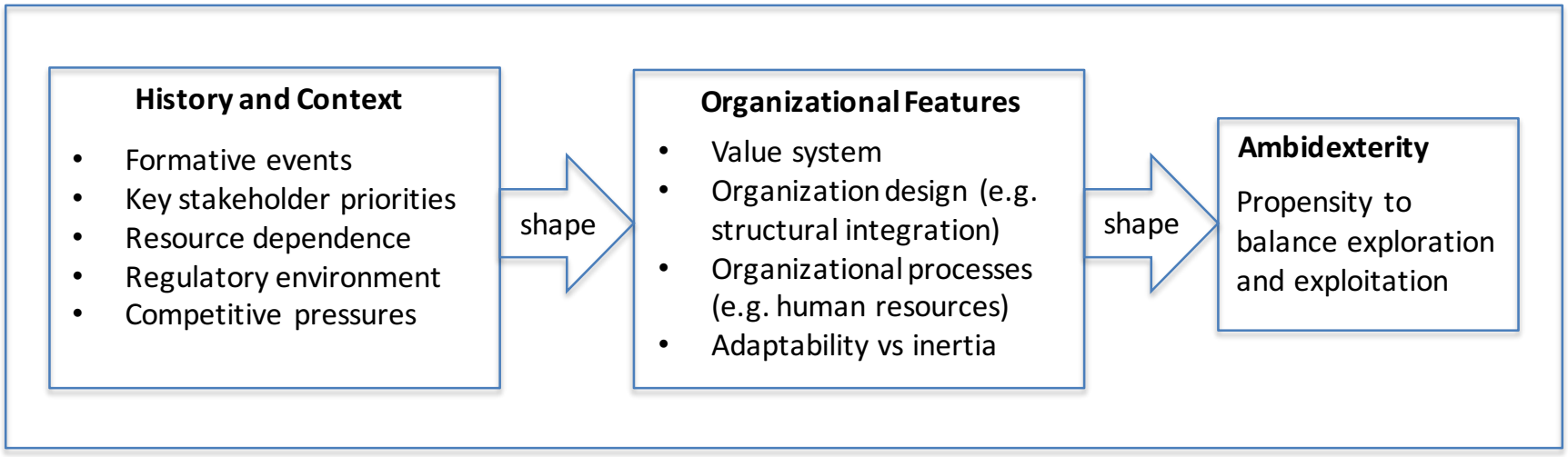

Table 1

Second Order Themes and Representative Quotes

Second order themes	Representative quotes
Cultural foundations	Much of NASA's early culture existed before NASA was created, in the predecessor organizations that came together to form the civilian space program … Many agencies incorporate conflicting cultures. This often results from the practice of amalgamating separate institutions, each with its own distinct culture, into governmental conglomerates. Institutions so created tend to be confederations of cultures rather than one culture fit to a common mold. NASA fits this description particularly well (McCurdy, 1993: 6-7)
	NASA also established other centers around the country devoted to specific purposes, some of them in support of the other centers … The assembly of existing organizations produced a confederation of cultures (Tomkins, 2005: 56)
	Currently, NASA's complex of centers operate quasi-independently rather than as an integrated capability. This has led to competition between centers, duplicative and sub-critical development efforts, and program assignments that are best described as counter-intuitive (such as experimental and development work at centers with no expertise in those areas) (National Research Council, 2012: 48)
	From the perspective of organizational evolution, there has never been a single, cohesive NASA culture … The fact that all but a handful of NASA centers were taken over from other organizations fuels the divergence of center cultures from each other and from headquarters (Space Foundation, 2012: 17)
Personnel characteristics	Much of the insistence on in-house work and contractor oversight was based on the pride that the NACA and ABMA employees had in their own capabilities … Another way that NASA officials maintained the agency's technical capability was by offering their employees the opportunity to do hands-on work (McCurdy, 1993: 41-42)
	the original technical culture of NASA assumed the need to recruit and keep the best and brightest from U.S. colleges and universities. ... Personal experience confirmed this element for me; the NASA employees of the original technical culture were indeed exceptional (Tompkins, 2005: 61)
	The lay-offs had a devastating effect on agency morale. With the flow of new blood constricted, NASA began to show signs of age. The work force grew older. The number of young people entering the work force declined. Engineers and scientists, the core professional group within NASA, advanced in years (McCurdy, 1993: 104)
	The distribution of work among NASA centers in recent years has favored the sustainment of all the centers … over establishing and maintaining centers of excellence … This has in part resulted from … the legal prohibition on NASA from applying regular reduction-in-force (RIF) governmental policies to its civil servants. As a result, some civil service staff are retained even when they are no longer needed at their assigned center (National Research Council, 2012: 47)
Bureaucracy	NASA's organizational culture reached its apex during the preparation for the Apollo flights to the moon. Technical discretion and organizational skill balanced each other. That balance proved to be ephemeral. As NASA matured, the technical culture grew weaker. So did the centralizing forces brought in to manage Project Apollo. In their place a more conventional form of government organization arose. NASA grew bureaucratic (McCurdy, 1993: 98)
	NASA's expanded use of contractors resulted in additional administrative structures and procedures to coordinate and control NASA-contractor relations. During this same period, all aspects of government were contending with increased oversight … professional accountability struggled to survive as the agency adopted the trappings of bureaucratic accountability (Vaughan, 1996: 211)
	Over time NASA has evolved into a very large government bureaucracy with a vast range of employees, labs, centers and specialized facilities, along with a host of high-technology corporations that live off NASA contracts (Pelton, 2006: 222)
	Bureaucracies usually try to mitigate risk by adding procedures and regulations to existing practices … Many NASA activities end up being planned almost as rigorously as human spaceflight. This introduces rigidity, increased transaction costs, and inefficiences in areas where a purely technical approach to risk management is not appropriate (Space Foundation, 2012: 21)

Table 1 (continued)

Second Order Themes and Representative Quotes

Second order themes	Representative quotes
Stakeholders and goal uncertainty	These power relationships between NASA and its external stakeholders – the government, private contractors, and space station partners – created an environment of problems where NASA, the focal organization, is dependent on resources on members of its external coalition with little or no recourse to limit that dependence (Garner, 2006: 379)
	Organizationally, NASA has been shaped by external forces driven by symbolic needs rather than technology, and the result has been an identity crisis for NASA as a technology-based agency. The fact that the agency has been constantly trying to respond to this dichotomy since the end of the Apollo era further exacerbates the problem, and has direct implications for NASA's future (Johnson-Freese & Handberg, 1991: 434)
	NASA's challenges are evident in budgetary politics between the branches and within Congress. With the exception of just three years since the agency was created … inflation-adjusted congressional appropriations for NASA have fallen below presidents' requests ... The divergence between NASA's long-term programmatic commitments and appropriations cuts could not be more evident for the success or failure of the agency's programs. The result has been to jeopardize NASA's ability to engage in strategic, long-term planning for the implementation of human spaceflight and other large-scale programs (Conley & Cobb, 2012: 52)
	As the space program has evolved, we have witnessed frequent redirection and constantly shifting priorities at NASA, mixed signals from Congress and the administration, organizational conflicts, and the lack of a singular purpose, resulting in a space agency without a clear, stable direction (Space Foundation, 2012: 1)
Pressures for efficiency	At the height of Cold War competition, ballooning cost and size did not seem to matter. NASA and Air Force executives adopted cultures of competence that put project performance well above concerns over cost and size. When the easy money days disappeared, aerospace executives found themselves with an intractable problem (McCurdy, 2001: 88)
	The aftermath of John F. Kennedy's historic ''man on the Moon'' speech in 1961 sparked the ''space race'' between the United States and the Soviet Union as each struggled to prove its technological superiority. Cost concerns were of less importance during this era as nothing could be spared to beat the Soviets to the Moon. However, at the end of the era, NASA experienced substantial budget cuts (Hall, 2003: 240)
	The Commission is convinced that NASA's business culture must be changed to embrace a significantly different role for itself in our space exploration enterprise. NASA needs a much-improved capability both to learn from and partner with a more robust space industry. The new NASA will be frugal and more nimble … The Commission believes that NASA needs to transform itself into a leaner, more focused agency (President's Commission, 2004: 21)
	Despite its significant accomplishments, NASA's funding has fallen to historically low levels (adjusted for inflation) … squeezing the agency's ability to develop new missions for human exploration, astronomy, planetary science, Earth science, solar science, technology development, and aeronautics research, which has led to cost and schedule inefficiencies for ongoing programs and missions (Space Foundation, 2016: 2)
Increased regulations, inflexibility	Since 1965 … the federal government has adopted 60 new public laws, 25 Executive Orders, 16 OMB circulars, and 24 Office of Federal Procurement Policy letters dealing with just contracting policy. Joined with civil service regulations and legislative oversight, these developments have enlarged NASA's bureaucratic burden and reduced the flexibility needed to manage the technically difficult space program (McCurdy, 1992: 191)
	The procurement regulations under which NASA was obliged to operate grew more complicated … The federal civil service agency restricted NASA's use of excepted and nonquota positions to attract top-rate professionals with higher pay ... Other federal regulations swelled: accounting standards, affirmative action, requirements for peer review, occupational health and safety, environmental protection ... Individually, each change had a worthy objective that led to its enactment. Together, the changes produced an appalling growth of bureaucracy (McCurdy, 1993: 110-11).
	Rules and regulations have, over the years, served as sort of mechanism for the preservation of institutional knowledge and various lessons learned, but without the formal review, challenge, and discussion mechanisms embedded within the standards process. The result is that many of these regulations have become an overconstraining mass of procedures and checklists (Space Foundation, 2012: 61)
	Legislative and regulatory limitations on NASA's freedom to manage its workforce and infrastructure constrain the flexibility that a large organization needs to grow or shrink specific scientific, engineering, and technical areas in response to evolving goals and budget realities (National Research Council, 2012: 49)

Table 2

Environmental and Organizational Factors, Effect on Ambidexterity and Organizational Rationale at NASA

Environmental and organizational factors	Effect on ambidexterity	Organizational rationale
Decentralized fiefdoms, high unit autonomy and low internal integration	Both Negative and Positive	Low integration across units and duplication of activities increased costs. Common values and precipitating event of putting a man on the moon however brought units together. Separation of exploratory and exploitative units aided ambidexterity.
Cultural emphasis on reliability and technical excellence, vs cost control	Negative	Exploration is emphasized in the development of technology characterized by reliability and technical excellence; downplaying attention to cost control and efficiency in the process
Low workforce turnover, ageing demographics	Negative	It is challenging for older employees to be adaptable, due to the conservative nature of cognitive maps, shared norms, organizational routines and established practices
Burgeoning administrative resource over time, inertia, conservatism	Negative	Ambidexterity is facilitated by structures with low bureaucratic costs, and cultures that embrace both poles of exploration and exploitation; excessive administrative procedures foster inertia and conservatism that are not conducive to either pole
Growing legislative and regulatory constraints reduce adaptability	Negative	Higher legislative and regulatory constraints lead to higher level of internal resources focused on compliance and conservatism, leading to inertia, rather than enabling both poles of ambidexterity
Shifting state priorities, goal uncertainty	Negative	Shifts in priorities of key stakeholders that impact org goals means that the sunk costs of existing projects may not be optimized, impacting both exploration and exploitation
Temporal incongruence between funding cycles and NASA's project horizons	Negative to Neutral	Long project horizons combined with funding uncertainty can lead to sub-optimal return on investment since funding may not be aligned with project needs. But it can also foster commitment to doing things efficiently and adaptably to reduce these risks
Ambiguous or critical stakeholder stance	Neutral to Positive	Critical stakeholder stance can impact funding but may also increase commitment to become ambidextrous, so that stakeholder stance becomes more positive in future
Gradual tightening of government funding	Positive	Pressure on resources increases motivation to explore new ways of doing things more efficiently and adaptably, fostering process innovations and a culture of ambidexterity
Competition from private sector and other nations	Positive	Market pressure and discipline via competition helps to provide performance benchmarks, and sense of urgency, and can raise commitment towards competitiveness