Science Fiction Film as Design Scenario Exercise for Psychological Habitability: Production Designs 1955-2009

Regina Peldszus[1] and Hilary Dalke[2]
Kingston University, London, UK, KT1 2QJ

and

Chris Welch[3]
Kingston University, London, UK, SW15 3DW

Scenario building presents a valuable tool for the development of design concepts for unprecedented long-duration space missions. Aside from quantitative modelling techniques, one medium that routinely illustrates scenarios through speculative but manifested design concepts is science fiction (SF) film. Set and prop design in such films are sometimes the product of consulting, research and development efforts by multi-disciplinary teams comparable to, or including experts from, technical groups conducting pre-concept studies in the field of human space exploration. This paper presents results from a study into the production design of SF films, with special focus on the psychological challenges of extended spaceflight. The aim was to provide preliminary insight into the potential validity and application of SF film design in the context of scenario building for space, in particular at pre-phase-A stage of the system development process. The study consisted of two parts: the focus of the first was the systematic identification of a relevant set of SF productions and the description of products, environments and interactions portrayed in the films according to habitability criteria set out in the literature. The second part involved an illustrative case study reconstructing, from previously unpublished archive material, the main conceptualisation stages of the design of the food dispensing system in one particular film from the sample set, Stanley Kubrick's *2001: A Space Odyssey*. It is suggested that, in the particular case examined, the process of film production design development can be regarded as a space design study. The findings indicate that SF films offer a set of rich and detailed cases of design *concepts* and design *issues* that are of possible interest in the planning of long-duration missions. Concepts can be situated at the periphery of the range of traditional bodies of reference available to the system development process; issues can act as critical impulse of debate into future user needs and wants, thus helping increase the robustness of traditional scenarios. However, for this fictional approach to be truly meaningful and effective in a space scenario building context, future exercises should be conducted based on agendas set by space mission, rather than film, planners.

I. Introduction: Design Development vs Making-Of

In the history of human spaceflight, science fiction (SF) literature and film has assumed the role of a catalyst and has been acknowledged as an inspirational early influence on the careers of many space system developers, such as the chief designer of the Soviet space programme, Sergei Korolyov (Haining, 1986). Additionally, in the beginnings

[1] Doctoral Researcher, Design Research Centre, Kingston University, Knights Park, Grange Road, Kingston, KT1 2QJ, UK, AIAA Affiliate Member.
[2] Professor of Design, Design for Environments, Design Research Centre, Kingston University, Knights Park, Grange Road, Kingston, KT1 2QJ, UK.
[3] Principal Lecturer in Astronautics, Astronautics and Space Systems Group, Kingston University, Roehampton Vale, London, SW15 3DW, UK, AIAA Associate Fellow.

of human spaceflight, SF writing was used to analyse, communicate, and promote space and technology futures among the general public through description of detailed mission scenarios by both designers and writers (Clarke, 1972; von Braun,1971).

Later, when real-life developments caught up with the second-guessing of fiction, the symbiotic relationship between SF and the space industry developed especially in terms of film design. This mutuality is evidenced in the anecdote that Wernher von Braun urged the designers at Raymond Loewy's office working on Skylab to go and see *2001: A Space Odyssey* for its "excellent design" (Zukowsky, 1999). For his 1968 film *2001*, director Stanley Kubrick and his co-screenwriter Arthur C. Clarke developed an entire scenario of a future set in 2001. They gained access to materials from the laboratories of key corporations of the time (Eichhorn, 2004), and over a four-year period liaised with more than 100 companies (Fischer, 2004) in addition to establishing their own staff of 105 production designers and technicians (Castle, 2005). Kubrick's intense preparation impressed his scientific consultants (Bernstein, 1970; Ordway, 1970), many of whom, such as technical lead Fred Ordway, went on to work on the production for 18 months. A substantial amount of time was spent visually documenting the built environment of real space research during fact-finding trips to NASA centres, and discussing designs with high-profile human spaceflight representatives, such as Apollo administrator George E. Mueller, who visited the studio workshops at early stages in the set development process. The aim of this dialogue was to produce 'accurate' spacecraft embedded in a wider scenario of a possible future, which included infrastructural, commercial and political conditions as well as technical ones. The reciprocity between SF design and real spaceflight is illustrated also in many other cases where designers and directors either consulted advisors or worked with space agencies, went on fact-finding trips, referenced space developments, or shot on location in space facilities (Boyle, 2007; Fleischer, 2005; Soderbergh, 2002). Possible cross-pollination between SF and real space systems development does not express itself so much in direct transfer of technology, but rather in an anticipation of future human needs and wants in a technology-reliant setting.

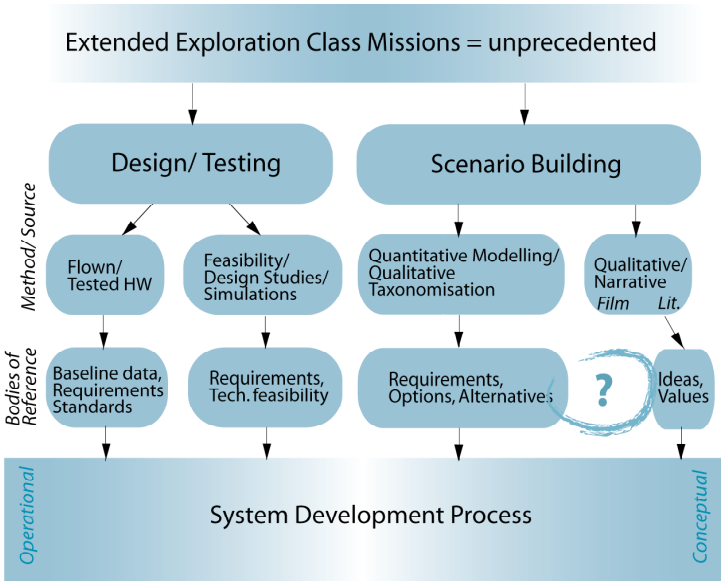

Figure 1. The body of reference available in the space systems development and the position of science fiction.

Today, within a real space context, scenarios, or fictional and narrative elements, are to be found mainly in training and simulations involving the controlled staging of events (Baranov, 2001). They are also increasingly used in immersive virtual environments for training, mission support, distributed collaboration and public engagement (Noor, 2010) such as NASA's Massively Multiplayer Online Game *Astronaut: Moons, Mars and Beyond*. Methodologically rooted in a tradition of speculation-by-default for unprecedented missions, fiction, however, could also be applied to future systems planning and development to produce design references or instigate discussion. Traditional bodies of reference available for consultation during the system development process are situated across a spectrum of operational practice and conceptual abstraction (see Fig.1). They include standards based on baseline data from flown or tested hardware and software, and specific design studies establishing options and requirements. Considering the logistical and financial challenges and long timelines of testing systems – let alone iterations of systems – in a real setting, scenario building, initially derived from operational research, has found its application mainly in the quantitative modelling of options and alternatives to underpin assumptions for system requirements. Qualitatively, for instance through describing and grouping issues verbally, it can highlight not just the "*most likely* scenarios … but *plausible* and *important* scenarios [his italics]" in highly unpredictable space futures (Huntley et al., 2010). Similar systematic reflection and qualitative taxonomisation has been used in a space human factors context, for instance to produce a catalogue of latent social, behavioural or environmental challenges with related design implications (Dudley-Rowley et al., 2003). Points such as these are then translated into anticipative but

feasible designs in conceptual architectural design studies (Imhof, 2007) in response to a general reference mission narrative. It is at this anticipative interface of psychology and the built environment where also the entirely fictional designs of SF could slot in. These designs are most tangibly manifested in film.

The body of reference these films constitute would be positioned on the periphy of conceptual development (Fig. 1). Of course, habitability requirements of human-rated space systems which address human needs in space clearly differ from those of film sets aimed at intellectually and audio-visually exciting an audience. Undoubtedly the scientific consultants, if involved in production at all, want to accurately portray realities, but for the film development teams and designers this is only one of a number of factors to be taken into account (Kirby, 2003). Thus, even if SF film is understood as an illustrated scenario, commercial and artistic agendas would have to be isolated from the designs. Nevertheless, production design is created in response to, or as illustration of, a mission scenario. Scripts and designs are frequently co-developed with space experts, and plots, characters and designs reflect on issues pertinent to the psychology and built environment associated with long-duration spaceflight. Some justification may therefore be attributed to the effort of investigating whether SF can build a body of reference or critical impulse for space systems development. While SF is subject to investigation in a general technology context (see section II B), the area seems to have received little attention in a spaceflight context, aside from one study into technology aspects of SF literature (Raitt, 2001) and from a public perception perspective (Miller, 1993). At the same time, the role of fictional elements in architecture and design is subject of a new distinct research area in a terrestrial context (see II A). Yet another argument, however, may be the size of this possible body of reference. While there are many conceptual design studies for space habitation (for instance Häuplik et al., 2003; Cockell, 2006; Barker, 2008), the potential of an *additional* set of designs produced with considerable budgetary and man-power effort – this study identified 30 possible cases – is worthy of examination.

Finally, in the light of a recent debate unfolding on new directions and paradigms in space architecture and design (Robinson et al., 2008), the following question emerged: Can we use SF design as a body of reference or critical impulse for habitability systems development? If so, then how? The first step towards an understanding of the content and process was to establish the body of reference itself by identifying a relevant selection of films, and describing their designs according to habitability criteria from the literature. The intention was then to produce a preliminary evaluation as to the potential of these designs to inform future space systems development in terms of design concepts (i.e. novel ideas or redesigned existing applications) and design issues (i.e. illustrations of human activity that could act as impulse for debate into user requirements). Addressing this small but possibly insightful niche in the current literature is the scope of this paper.

It will be structured as follows: a background section describes SF films as design studies, highlights the main issues in the emerging field of design fiction, and outlines possible benefits to the space development context. A short section then summarizes criteria of psychological habitability as utilised in the methodology. The method describes the systematic identification and subsequent content analysis of 30 SF films from 1955-2009 with settings deemed comparable to long-duration space missions. This is complemented with a reconstruction of the design development process of the food dispensing system of *2001: A Space Odyssey*. The discussion proposes a number of design concepts and issues of potential interest to the space designer. The paper concludes with an indication of the role and potential of this kind of design activity for space, and points out related further research.

II. Design Scenarios & Space Systems Development

A. Design Fiction as Scenario Building

Fundamentally narrative in nature, scenarios act as a predictive, explorative or normative (Borjeson, 2006) tool to structure thought (Liotta & Shearer, 2007). Scenario-building has become increasingly valued in providing a platform to recognize, consider and reflect uncertainties in a complex industrial or technological setting (Varum & Mello, 2010). Design fiction can address fuzzy design problems characterised by complex networks of trade-off and interdependency. The activity aids through "learning about the structure and dynamics of problem domains, seeing usage situations from different perspectives, and managing tradeoffs to reach usable and effective design outcomes" (Carroll, 2000). The central point here is not only the acknowledgement but the acceptance of ambiguity as opportunity, in opposition to simplified, specification-driven design (Carroll, 1995). Emphasis is primarily placed on precision, not accuracy (i.e. a persona has to be described in detail, but does not have to be "correct", i.e. true or real) in order to elicit meaningful data on possible future design decision (Cooper, 2004).

In industrial design development, one of the key processes for the visualisation of design solutions has become story-telling (Moggridge, 1993). Used beside traditional scenario building methods, narrative approaches (McCarthy, 2004) and speculative design practice present useful methods to "explore" new scenarios (Rust et al.,

2007; Blecic & Cecchini, 2008). Developing fictional portrayals (i.e. stories involving characters, events, products and environments) allows the designer to explore product ideas and issues in the context of a realistic future (Suri & Marsh, 2000). Those stories act as tool for envisioning new systems, structuring mock-ups and evaluating prototypes (Rizzo & Bacigalupo, 2004). They deliver potentially fundamental insights (Schneider, 2005) into the interaction between humans and the constructed environment surrounding them, including the mundance aspects of everyday routine (Carroll, 2000), even the potential subversion of the system or setting through its agents (Blythe & Wright, 2006). The user is advanced into a character or specific persona placed in fictional but feasible settings (Nielsen, 2002). The representation of scenarios through prototypes, use of storyboards, video, rapid prototyping tools and stories, annotated sketches, cartoons, photographs, role-playing or live dramatization (Suri & Marsh, 2000), allows the vision conveyed through the scenario to be opened up to critique (Carroll, 2000).

Design, here, does not assume the traditional role of problem-solving, but acts as a critical agent in the enquiry about real human needs and values by evoking reflection (Carroll, 1995) and stimulating debate amongst designers, industry and the public (Dunne & Raby, 2001). This critical strand in design, termed speculative design, critical design or design fiction, has emerged as a field in its own right and is establishing itself with the main markers of a new discipline, such as seminal publications (Dunne, 2005; Antonelli, 2008), exhibitions and conferences.

In any design process, the continuous alternation between abstraction and practice is vital. In space systems engineering, this is expressed as the process of successive refinement (NASA, 2007). In industrial design it is referred to as the alternation of reflection and action (Schön, 1987). The methodological status of design fiction and scenario building as an academic field remains the subject of vivid debate. Its reflective properties, however, and its key elements of multidisciplinarity and use of intuitive logic (Barbieri Masini & Medina Vasquez, 2000) situate it as a valid complementary design tool not only in a consumer context, but also, potentially, in a space technology setting, where addressing uncertainty is critical to the success of autonomous missions (Horneck et al., 2003).

B. Science Fiction Film as Design Study of a Space Mission Narrative

The narrative nature of literature-based SF can be useful on its own during the process of building broad scenarios (Miles, 1993). In its relevance to a number of contemporary issues surrounding the meanings and implications of science and technology (King & Krzywinska, 2006), the scenario character of science fiction – its effectiveness of elicitation of ideas and information – has been acknowledged (Norman, 2004). In a broader socio-technological context of the futures and foresight fields, SF is already the subject of studies on technological developments, social acceptance, scientific accuracy (Dubeck et al., 1994; Carrell, 1973; Nicholls, 1983), or more topical aspects such as the role of artificial intelligence (Larson, 2008).

In the context of human-computer interaction, SF is giving way to social or value fiction (Thakara, 2006; Dunne, 2005) where emphasis is placed not merely on technological extrapolation but on scenarios of human activity, reflecting the trend in scenario-building or design as outlined above. As an elicitation exercise in its most extreme form, pastiche scenarios draw on fictional characters outlined in great detail in narrative literature (i.e. novels) to "explore the interior 'felt-life' aspects of user experience and the complex social and cultural issues raised by technological innovations" (Blythe & Wright, 2006). In this context, SF is pointed out as the most obviously relevant literary genre for human computer interaction (ibid).

It is, however, when abstract narrative and architecture merge in moving image into a concrete science fiction (Oosterhuis, 2002) that the description of future settings becomes an illustration of scenarios of possible human activity. In its ability to create alternative, radically different and hypothetical worlds, SF, as applied to architecture, presents a form of design "that interprets a fictional vision into a strategy for approaching a new problem, or inventing for future communities" (Armstrong, 2000). While both film and literature are subject to research in a general cultural and technological field, the content of SF films, however, appears to have received less attention from a space design perspective. Analyses have focussed mainly on the relationship of SF literature with public perception and technological development (Miller 1993; Warmbein, 2004). However, albeit not yet in human factors or habitability, an ESA study data-mined SF literature for concepts of propulsion, energy, and communications, amongst others (Raitt, 2001). This was based on the rationale that concepts situated outside mainstream science might have been overlooked in the past, but could provide a "kickstart" today with the specific aim of aiding future systems development (ibid).

There are parallels in the constitutent components of scenarios, films, and mission 'narratives'. Films consist of a narrative plot, characters, and environments and objects situated in a historical, social, political setting (Newman & Stafford, 2002). Scenarios contain goals, agents, and settings (Rizzo & Bacigalupo, 2004; Carroll, 1995). Space missions can be broken down into mission objectives, human elements and systems (hardware and software) situated in an external physical, social and political (programmatic) setting (NASA, 2007).

III. Psychology and Design in Space and Science Fiction

A. Psychology and Space Habitation Design

Long duration missions pose several challenges to the spacecraft inhabitant that are critical to mission success. In their summary of stressors, Kanas & Manzey distinguish between physical, habitability, psychological and interpersonal stressors that include isolation, confinement, monotony, gender and cultural effects, and personality conflicts (2003). In order to address psychological challenges, two main approaches to the provision of psychological countermeasures are described in the literature (ibid). One addresses the preparation of the individual to cope with the stressors, and the other adapts the built environment to the requirements of the inhabitant (ibid).

On a conceptual and operational level, this second notion is the central task of design for habitability (Morphew, 2001). Habitability is understood as integrated space architecture and as the "unifying concept" for the system design of a space habitat (Celentano et al., 1963) and as self-evidently crucial factor by both mission planners and space architects today (Imhof et al., 2004; Howe & Sherwood, 2009).

From a psychological perspective, there are four main areas of general concern for habitability. These are personal quarters, crew interaction and leisure, interior décor and windows (Kanas & Manzey, 2003). Psycho-environmental design recommendations specifically include countermeasures to address social and sensory monotony and boredom through habitability components such as interior design, food, special occasions, personalisation and leisure applications (Suedfeld & Steel, 2000). From a built environment perspective, habitability has been taxonomised to varying degrees of detail (Bishop, 2006; Blume-Novak, 2000; Celentano et al., 1963; Connors et al., 1985; Fraser, 1969; Morphew, 2001; NASA, 1995; Stuster, 1986) since the advent of long duration space misions.

B. Psychology and Fictional Space Habitation Design

There is some anecdotal evidence on the psychological effects of set designs on the "inhabitant" actor in featurettes or audio commentaries on recent DVD releases. Thus, actors felt melancholy, such as Dullea in *2001* (Leva, 2007), or tension and confinement like Hurt and Weaver in *Alien* (Lauzirika, 2003) on set. Comparable to the twofold approach of psychological countermeasures, the effects (desired by the director) are evoked by strategies that either address the preparation of the actor or the design of the built set environment. Mimicking the first approach of countermeasure involved training of crew (*Sunshine, Voyage to the Planets*), deliberate manipulation of group dynamics (*Alien*) or withholding of information on idiosyncracies of set, special effects or turns in the plot (*2001, Alien*) (Lauzirika, 2003; Jones, 2009; Mueller, 2007). In the second approach, entire closed habitation models were built on stage (*Moon, Alien, 2001*), creating deliberately confined or unpleasant aspects such as pressure doors or small corridors and dark lighting, such as in *Cargo* (Noger, 2010).

Audience reactions to the actual set designs are more difficult to isolate from their responses to other stylistic means in the films documented in contemporary critiques. It can, however, be assumed that sterile designs and slow pace in *2001*, for instance, will have contributed to the boredom some viewers initially experienced while watching it (Geduld, 1973).

IV. Method

The study consisted of two parts conducted in parallel between 2008 and 2010. Part one comprised of the identification and visual content analysis of 30 SF films comparable in plot to a long duration mission setting. Part two utilised archive material and original interview data to reconstruct the design development of the food dispensing system in one of the films of the sample, *2001: A Space Odyssey*.

A. Content Analysis

1. Sampling

The aim of sampling was to identify the subset of texts from all existing SF moving image works that featured scenarios comparable to a long duration spaceflight (LDSF) with a duration of more than a month, a crew size up to fifteen people in an isolated human-rated vehicle, base or station in either an orbital, surface stationary or itinerant location. The selection process involved the individual evaluation of written descriptions of 1066 SF films and television productions, which the authors estimated as the total number of science fiction films produced to date (720 covering 1902-1983 (Hahn & Jansen, 1983); 346 from 1983-2010 (Lance, 2005; BFI, 2010), synchronised for overlaps).

All non-space related texts were excluded (e.g. *Metropolis, Fantastic Voyage)* In addition, all those works which, although space-related, were not actually or predominantly set in space (e.g. *The Matrix, Contact, The Right Stuff*) were also excluded, leaving a population of 144. This short-list was then checked for other non-LDSF related components. This included points such as the a priori assumption of alien entities or civilisations (as opposed to their discovery later on in the film), non-human crews, plot scenarios with large-scale universe colonisation or multiple universes, and time and dimensional travel (this excluded productions such as *Star Trek, Flash Gordon, Battle Beyond the Stars*). The resulting group of 81 was then evaluated in more detail through sighting of synopses (BFI, 2010) or viewing of excerpts and trailers, and tagged according to mission duration and scenario. In addition, any works that featured detailed replicas of real space hardware in accounts of historical or fictional contemporary missions (*Space Cowboys, Apollo 13*) were also excluded. This resulted in a sample of 36 films of which 30 were available for viewing at the time of the study.

Table 1. Final sample of 30 films with a story ressembling a long duration mission scenario.

Country	Year	Title	Direction
US	1955	The Conquest of Space	Byron Haskin
USSR	1955	Doroga K Zvezdam	Pavel Klushantsev
GDR/PL	1959	Der Schweigende Stern	Kurt Maetzig
USSR	1962	Planeta Bur	Pavel Klushantsev
CSSR	1963	Ikarie XB!	Jindrich Polak
UK	1968	2001: A Space Odyssey	Stanley Kubrick
US	1968	Mission Mars	Nicholas Webster
GDR/ PL	1970	Signaly	Gottfried Kolditz
USSR	1972	Solyaris	Andrei Tarkovsky
GDR/USSR/BULG	1972	Eolomea	Hermann Zschoche
US	1972	Silent Running	Douglas Trumbull
USSR	1973	Moskva-Kassiopeya	Richard Viktorov
US	1974	Dark Star	John Carpenter
GDR	1976	Im Staub der Sterne	Gottfried Kolditz
UK/US	1979	Alien	Ridley Scott
USSR	1980	Petlya Oriona	Vasili Levin
UK	1980	Saturn 3	Stanley Donen
USSR	1981	Cherez Ternii K Zvezdam	Richard & Nikolai Viktorov
US	1984	2010: The Year We Make Contact	Peter Hyams
US/UK	1986	Aliens	James Cameron
US	1997	Event Horizon	Paul W S Anderson
US	2000	Mission To Mars	Brian DePalma
US	2000	Red Planet	Anthony Hoffman
US	2002	Solaris	Steven Soderbergh
UK	2004	Space Odyssey: Voyage To The Planets	Joe Ahearne
CAN/FR	2007	Race To Mars	George Mihalka
UK	2007	Sunshine	Danny Boyle
FR	2008	Dante	Marc Caro
US	2009	Moon	Duncan Jones
UK/US/CAN/GER	2009	Defying Gravity	James D Parriott

The sample is distributed evenly over six decades between 1955-2009 and includes productions originating in eleven different countries. Most of them feature itinerant space vessels, and three bases and one station. Crew numbers were established and vary between one and fifteen with a mean of six. Gender or national and professional cultures were not established in detail, although crew types ranged from a one- man crew to mixed, 50:50, all male,

or mixed with female commanders. Mission types might therefore provide some additional design-relevant information. In most of the thirty cases, general scientific objectives (including search and rescue) were the major scenario/narrative drivers, with five works being based on military requirements, three on commercial ones (freighting/mining) and one on a prison environment. Budgets were not taken into account, but data was compiled on directors, designers (set, production, concept art) and scientific and technical advisors.

2. Coding

Codes to decribe the scenarios and their design features were created from the parameters of habitability highlighted in the literature (See Section II). After two initial tests of the coding system, the structure was amended so that it consisted of four groups: general environment, activity zones, provisions, and additional aspects. Coding was open within these sub-categories, i.e. it involved describing, rather than simply establishing, the occurence of a code (Alexander, 2009). There was no formal testing of inter-coder reliability.

Table 2. Codes for visual analysis based on habitability categories derived from the literature.

Activity Zones	Environments	Provisions	Occupation
Sleep	Colour Schemes	Furniture/Fixtures	Personalisation
Leisure	Illumination	Clothing	Special Occasions
Hygiene	Decor	Food	*Other*
Exercise	*Other*	Entertainment/Leisure	
Galley		Exercise	
Observatory		Companions	
Walkways		*Other*	
Greenhouse			
Infirmary			
Other			

3. Units and Viewing

The films added up to approximately 59 hours of footage, with an unspecified but substantial duration of footage inside the relevant spacecraft. These scenes amounted to the units to be coded. Within these units, those components belonging to the mis-en-scene were considered (Newman & Stafford, 2002), including interior architecture and setting including colour, props and costume design.

All films were viewed by at least one coder (the authors), most of them in full length once in either English, German, or original language with English subtitles, and stopped or repeated at convenience to record written notes in a pre-produced coding table. A small number of films was only available in extended trailer format at the time (e.g. *The Conquest of Space*), and several productions were seen in successive clip format on YouTube and other internet delivery platforms. Some productions were viewed without subtitles in Russian or Polish and could not be understood by the authors. In one case, advice was sought from a native speaker to elucidate the context of a particular design aspect. In most cases, however, the similar typology and morphology of design features made a visual analysis possible without additional verbal explanation. The raw data was transcribed and tabulated.

B. Case Study: Development of the Food Dispensing System in *2001*

1. Case Selection

The aim of the case study was to reconstruct the main stages of the concept design development of a habitability aspect of one of the films. The spacecraft *Discovery* in *2001: A Space Odyssey* was selected due to the film's critical acclaim and influence, wide evidence of scientific counsel and clear depiction of day to day routine habitability aspects. An additional factor in this choice was the accessibility of data on the film in the research collection available at the recently opened Stanley Kubrick Archive at the London College of Communications, London (2008-2010). Upon viewing of the film and sighting of the – then uncatalogued – items from the collections during a first visit, it was decided to concentrate on the development of the food system which features prominently in the film and which also promised reasonable return in terms of locating associated documentation.

2. Collection of Primary Data: Archive Material and Interview

The archive was then accessed several times in November 2008 and between February and March 2010. Focus was placed on pre-production and production aspects of the film. Hundreds of slides, transparencies and contact

sheets were sighted, detailing set designs, costumes and props. In addition to this, many other artifacts were seen: hundreds of pieces of correspondence from Kubrick's staff to stakeholders, suppliers and designers (letters, packlists, telegrams, delivery notes including fabric samples, notes, call notes); several dozens of sketches, drawings and photographs of set development and production; a number of Kubrick's personal notebooks; two production notebooks detailing built aspects of the plot; callsheets, and one annotated screenplay draft by Arthur C. Clarke. Of particular interest were approximately 400 additional slides taken by scientific advisor Fred Ordway, Kubrick's assistent Ray Lovejoy and Arthur C. Clarke during their fact-finding trips to several NASA centres, as well as the production notes and design development sketches of consultant companies, such as IBM and American Express, in original drawing format or slide transfer. Additional data was obtained during one informal and another 90-minute semi-structured interview using open-ended questions with one of the art department staff of the movie who worked on models during pre-production and production. Notes were taken in writing.

V. Results

A. Content Analysis

1. General environment

Colour and Illumination: Pre-millenium colour schemes were predominantly bright or off-whites throughout the sample, followed by silver and aluminum interiors. From 2000 onwards a blueish grey stainless steel look dominates, albeit with some bright aspects of International Space Station (ISS) colour schemes (Fig. 2).

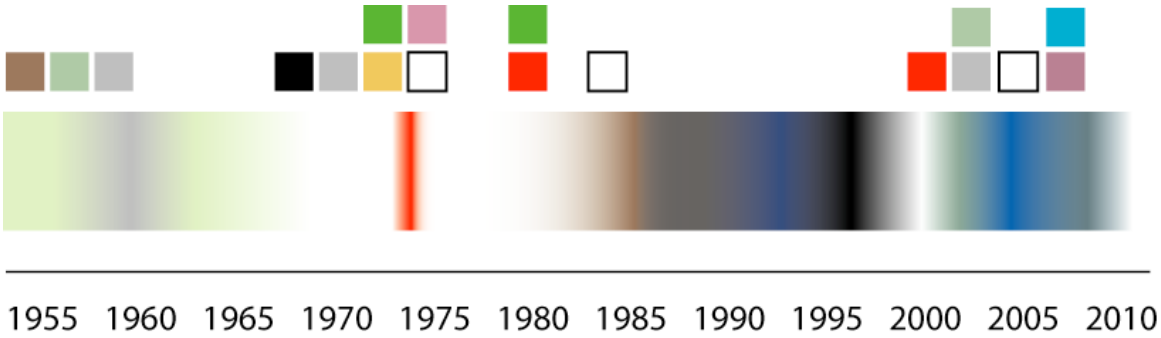

Figure 2. Main interior colours of spacecraft interiors across the sample.

More than half of the sets from 1959 onwards included either skylights, light-box style lit-up walls or table tops, even in the cases of general dark levels of illumination (*Alien, Sunshine*). The remainder showed fluorescent or strip lighting (those based on ISS designs from 2000 onwards), or featured no particular light sources (Fig. 3). Almost all cases featured coloured ambience and brighter task lighting, in a few cases adaptable. Two cases showed purely occasional light decoration. Another source of illumination was frequently provided by work interfaces and displays adjacent to the off-duty areas. Data on these was gathered but not analysed for this study.

Surface Decoration & Patterns: There was a distinct trend in surface patterns (17 of 30) that disguised or consisted of equipment and pipes, decorative or protective padding or pannelling. In several cases this appeared to be a hexagonal or geodesic grid pattern. Most patterns were embossed, in one case this included 3D cladding in combination with a lightsource across walls. Aside from general geometric patterns (generally angular but rounded in corners) that were similar throughout the sample, there were some idiosyncratic pieces of surface décor, including exposed clear pipes that captured surrounding light.

Other Environmental Aspects: The audio environment appeared less varied than originally assumed (again, data on caution and warning signals was gathered but not analysed, as more pertinent to work environments), with one notable exception of an arguably pleasant melodic signal for incoming communication in *Silent Running*.

2. *Activity zones*

Sleep: 22 of 30 films featured distinct crew quarters with either rooms with beds and bedding or separate alcoves opening to a walkway or directly into a galley. Differing degrees of privacy were afforded in all of them through opaque, translucent or transparent shutters, and to a certain degree in a 2-crew bunk on a 2-crew base (*Eolomea*). In one case (*2001*) transparent pods intended for hibernation and located essentially in the corridor/walkway were used for regular sleep with relatively little facilitation of privacy.

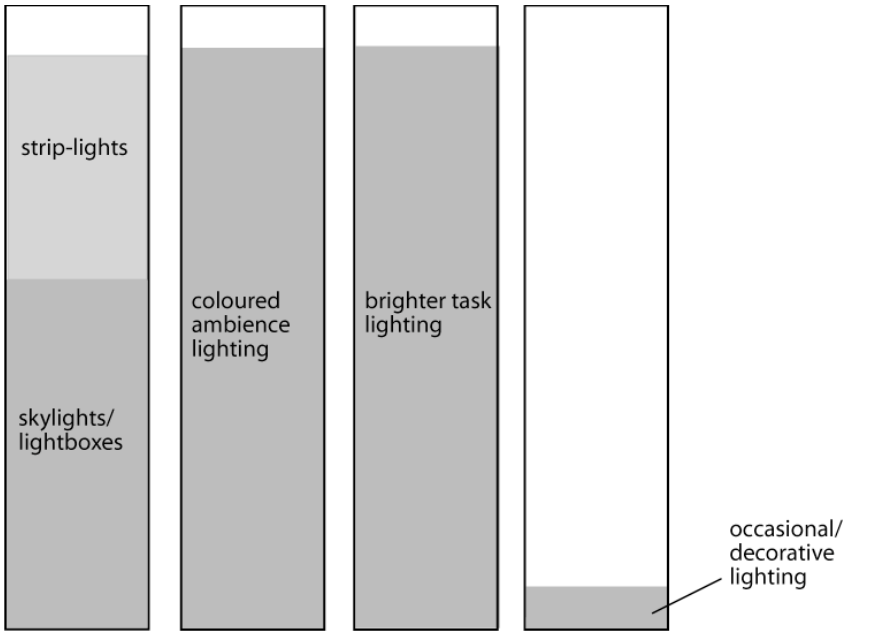

Figure 3. Types of lighting accross the sample, proportion of the sample displaying ambience, task and occasional lighting.

Sport & Leisure: From the thirty habitats, three across the sample (in the 60s, 70s, 2000s) featured a designated sports module. Seven habitats across the sample included separate leisure areas ranging from a simple multi-purpose room to a couple of wood-panelled libraries, yellow-clad common rooms with easy chairs or 'coffee table' areas (*Race To Mars*).

Galley: Seventeen, however, had a galley area that could double as meeting room with (mostly) movable furniture chairs, separate alcove or booth spaces. From the 80s onwards, a galley space was always included and used as a central meeting area.

Observation and windows: Seven films had a cupola style or panoramic observation deck with seating or social gathering facilities, and almost all films – but five – featured windows or portholes.

Personal & Medical Care: Half of the sample showed some kind of separate infirmary (mostly brightly lit and white with a central slab or bench for a patient), but only nine showed personal care facilities. Most of these, across the sample, featured mirrors, some elaborate showers, and one a simple collapsible tub. Only one showed a type of toilet made of stainless steel.

Other environments of interest: Two sets, chronologically more than three decades apart (*Moskva-Kassiopeya* and *Sunshine*) featured what would be described as a *Star Trek* style 'holodeck' concept. In the older version, this consisted of a separate room with a visual archive interface outside it from which to select a theme or location that would then be played out inside. More plausibly displayed in the newer film, the 'Earth-room' consisted essentially of an approximately $9m^3$ sized box with lit-up screens that would display a chosen moving image for therapeutic purposes. A similar restorative environment is created in a hospital on board the Earth-orbiting station in *Aliens* (not formally recorded in this analysis, as not part of the long duration spacecraft from the same film). This featured an artificial-natural hybrid of a lit-up wall showing a forest scene, fronted by real plants surrounding a seat.

Greenhouses: Plant-growth facilities, in one form or another, occur in many of the films, from the oldest film's symbolic planting of a seed in Martian soil surface, through to a 2007 walk-in 'oxygen garden' as integral part of the spacecraft's life support system. Variations included decorative plants in crewquarters and galley areas, experimental closed-loop growth chambers, terrariums and aquariums and, in three cases, plant or algae growth integrated in the structure of the spacecraft in transparent partition walls or in pipes of walkways. Aside from designated facilities, some plants appeared to be in Do-It-Yourself (DIY) greenhouses fashioned from left-over aggregates in the habitat, such as food containers in *Moon.* Notably, some spacecraft did not feature plants or plant growth facilities at all, including *2001, Alien, Dante,* and *Dark Star.*

3. *Provisions*

Furniture and fittings: Most environments foresaw some kind of easy chairs or casual furniture in synchronisation with the colour and style of the surroundings, and mirroring the contemporary style at the time of release, e.g. organically morphed pod-sofas and brightly coloured soft furnishings in the 70s. *Silent Running* features

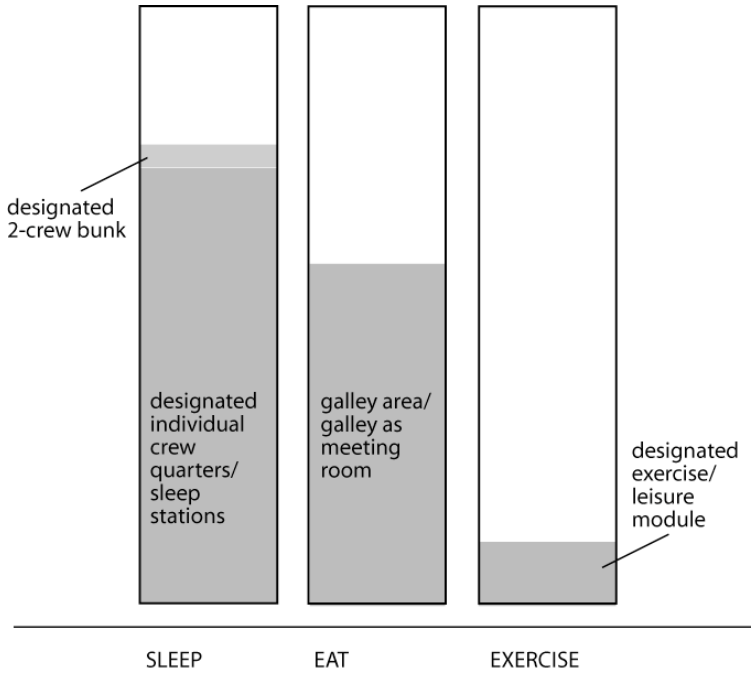

Figure 4. Provisions for designated activity zones.

a group of contemporay office chairs, while the very bright interior of the base in *Moon* is off-set by a large, scruffy brown vintage leather armchair that was clearly used on Earth, similar to old candle-holders in *Solyaris.* Additional items that were not classified as surface décor but neither as personal belongings came in form of busts and natural memorabilia, such as a coral-style sculpture and a model of a horse (*Solyaris, Defying Gravity*).

Clothing[4]: Across the sample, the most predominant form of clothing consisted of uniform-style overalls (21 of 30), plus one case of military fatigues. Since *Solyaris*, casual clothing featured mostly in Eastern Bloc costume design, until *Alien* introduced individual colour variations, prints (Hawaiian-style), and individual accessories such as bandanas and caps to western films as alternative to boilersuits. While most non-casual apparel was branded with mission patches or insignia throughout, from 2000 onwards a hybrid of branded casual uniform clothing (colour coded t-shirts, polos, waistcoats, cargo pants) reminiscent of ISS style clothing appeared (*Mission to Mars, Red Planet, Voyage to the Planets, Race to Mars, Defying Gravity)*, though different from the exclusively casual clothing of *Sunshine.* Additional occasional clothing is provided in many of the early films, including reconfigurable sequined collars (*Ikarie XB!)*, whereas later wardrobes tended to involve ironic motto t-shirts (cartoons in *Red Planet*; "Wake me when it's quitting time" motto in *Moon*). Wrist watches and wedding bands feature regularly throughout the sample. Apparently the first case of correcting glasses (a thick black frame) appeared in the 1970s, and so do sunglasses later on. Unexpected were the six cases of kimono-style or soft white (in one case floral) dressing gowns that were both used for lounging, ideosyncratic purposes (*Doroga K Zvezdam, Ikarie XB!, 2001, Silent Running*) or reconvalescence (*Alien, Moon*). Basic wear was

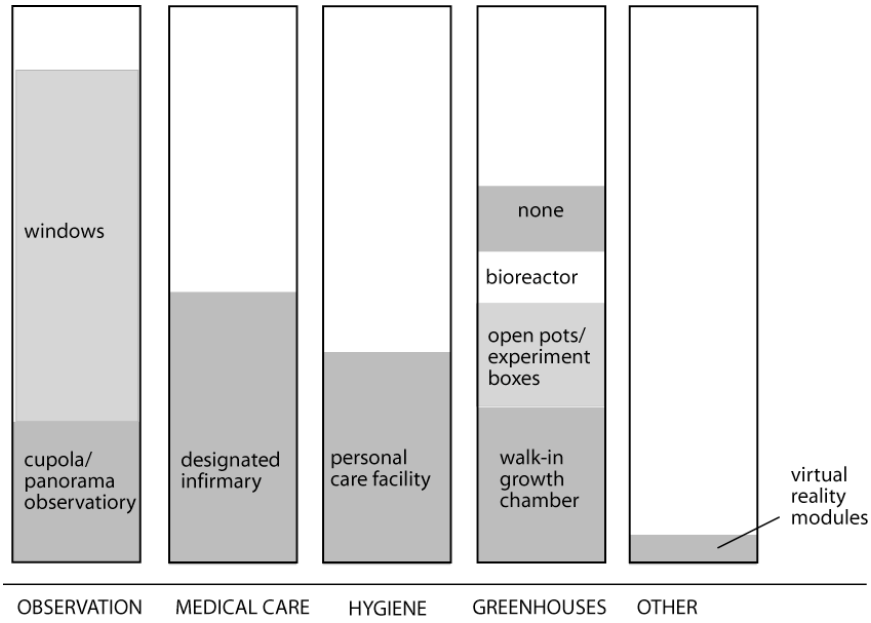

Figure 5. Additional activity zones, and breakdown of types of windows and greenhouses.

[4] Data on space suits was gathered, but not analysed here.

predominantly white, with darker exceptions in the more recent films.

Food & Consumables: Since the cup of tea in the first film of the sample in 1955, food provision, as reflected by galley environments, was a central aspect. It featured everything from fresh greenhouse fruit to pantry style modular provisions, rehydratable or reconstitutable packed rations to be selected or received as part of a bespoke computerised dietary plan (*Ikarie XB!*), to non-descript mash, liquids, or supplementary pills. No discernable timeline could be identified, and elaboration of food aspects seemed to be in no relation to otherwise intricate habitation aspects (*Der Schweigende Stern*), although condiments and sauces featured increasingly in the more recent films from 1979 (*Alien*) onwards. Utensils ranged from plastic or metal containers and cutlery (*Dante, 2001*), tubes, drink-bags with straws or drinking straight out of chemical beakers (*Red Planet*) to clear plastic crockery showcasing colourful contents (*Alien, Sunshine*), glasses and china-cups (*Solyaris, Signale, Cherez Ternii K Zvezdam*) and bento-boxes (*Ikarie XB!*) and simple chops-sticks (*Sunshine*). There was a range of thermal cups and soft-drink cans throughout. Most food dispensers were situated in the galley, with one particular configuration involving a drinking fountain/snack bar in the bridge area (*Im Staub der Sterne*). There were few cases of consuming sweets or chewing gum, although a fifth of the sample featured legal or illegal alcoholic beverages central to socialising or other occupational purposes. Nearly a third of the fictional spacecraft provided cigarettes or other drugs, including three cases of consumables in inhaler format (presumably nicotine), spray (some kind of mild narcotic) or patch (an apparently unsuccessful 'libido inhibitor') across the timeline of the sample.

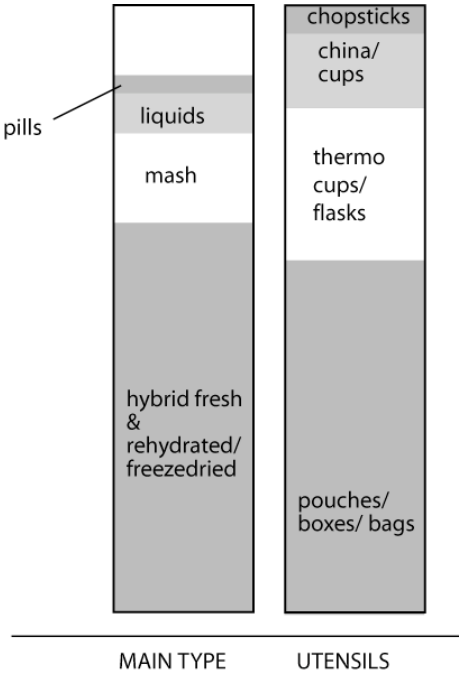

Figure 7. Main food types and peripheries.

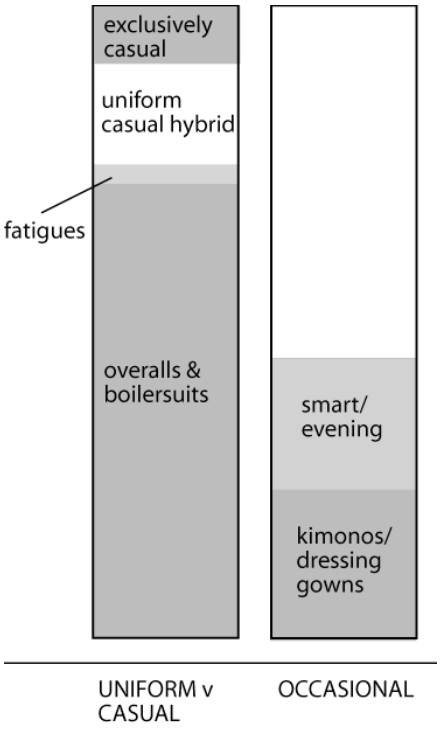

Figure 6. Breakdown of clothing, and proportion of occasional clothing with breakdown in main types.

Entertainment, Leisure & Exercise: Aside from designated leisure and exercise modules, the sets provide a multitude of product configurations. Favourite off-duty occupations consisted of games (15 cases including several occasions of ping pong, knife games, card play, snooker, cyrillic scrabble, chess and computer games). There were also books, magazines and news in analog and digital format as early as 1968 (13); music replay equipment (11); movie display (10); DIY, tinkering, craft (8); grooming and relaxing (6); personal science projects or solving maths problems (6); sports games, dancing, moving otherwise in μg (6); meditation and observation (5); surveying other crew members on close-circuit television (CCTV) (3); drawing and sculpting (3); gardening and animal tending (3); playing music (3); making movies (2); performing in front of others or playing practical jokes (2). Exercises included jogging, treadmill and flywheel exercise, segways, rope-skipping and, in an earlier film, one case of apparently isometric exercises and gymnastics.

4. Additional aspects

Aside from personalisation with pictures, photos, posters and pin-ups (18), crews customised their environment with soft toys, trinkets and charms (elephants, witches, birds, 'executive toys'), mottos like '29,000mph speed limit' similar to ISS (*Sunshine*), or 'Don't open before train comes to a halt' (*Eolomea*), as well as stickers and sticky notes. Most interesting from a DIY perspective were Christmas trees, musical instruments and birthday gifts created from onboard items (*Eolomea, Dark Star, Race to Mars*) in addition to ready-made decorations, costumes, gifts and cards for occasions like birthdays, burials, anniversaries, New Year's Eve, etc. Related provisions of interest include face paint or make-up (*Defying Gravity*), a selection of interchangable wigs (*Signaly*) and a kind of synthesiser to create objects for educational use in 1973's *Moskva-Kassiopeya*.

Other aspects of interest were the inclusion of natural or artificial crew companians ranging from dogs, cats, turtles and rodents to robots, board computers and/or androids in 17 of the films.

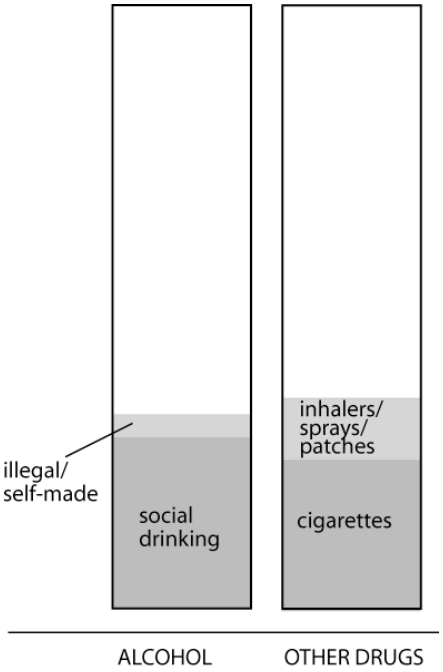

Figure 8. Additional consumables.

B. Design Development vs Making-Of: The Case of 2001

1. Organisations, Product Placement and Product Development

A list of organisations and companies who contributed to the product development process through consultancy, material loan or product were compiled from archive material (Letter of Polaris Productions Inc, May 4, "1967 to be credited as consulting firms" SK/12/8/2/71; SK Archive catalogue; files SK/12/8/2/133), and secondary data (Eichhorn, p. 122 and p. 144) (Table 3).

Table 3. Organisations shown or involved in the product development process of *2001*. Aeroflot was not consulted, but referenced in a flight bag.

[Aeroflot]	Dryden Flight Research Center, NASA	Minnesota Mining & Manufacturing
Aerojet Corporation	Food Technology Research Center	Mitchell Construction
Aerospace Medical Division	General Electric	NASA HQ
AIAA	General Motors	Nikon
American Machine & Foundary Co.	Goddard Space Flight Center, NASA	NY Times
American Express	Grumman Aircraft Engineering Corp.	Office of National Research
Ames Research Center, NASA	Hamilton Watches	Olivetti
Analytic Laboratories Ltd.	Hasselblad	Pan Am
AT T&T	Hawker Siddel Dynamics	Parker
Barnes Engineering Company	Hewlett Packard	Pepsi Cola
Bausch & Lomb	Hilton	Perkin-Elmer
Bell Telephone Inc.	Honeywell	Philco Corp.
Bendix Field Eng Corp.	IBM	Pitney Bowes
Boeing	Jet Propulsion Lab	Radio Corp America
Burroughs Tube Co.	Kodak	RCA Victor
Computer Control Company Corp.	Langley Space Flight Center, NASA	Samsonite
General Dynamics Corp.	Lear Siegler	Seabrook Farms
Coty Costmetics	Ling-Temco Vought Inc.	Skyway Luggage
Department of Defense	Lyle & Scott Underwear	Tote Systems International
Douglas Aircraft	Macy's	US Army Natick Labs
DuPont	Marcom	Vickers Ltd.
Eastman Kodak Co.	Marshall Space Flight Center, NASA	Whirlpool Corp.
Ehrenreich Photo-Optical Industries	Martin Company	Vogue

2. Design development process for the Food System of the Discovery

The design development of the food system used onboard the spacecraft *Discovery* was reconstructed by linking different pieces of evidence from the archive: SK/12/1/1/3 (Novel Script, Arthur C. Clarke, Chapter 9 and Chapter 27, p. 35); SK/12/2/7 (Kubrick's Diaries & Notebooks); SK/12/2/7 (Production Notes 1965, p. 68, 69 and 100); and SK/12/2/1/24/1-9 and SK/12/8/2/119 (pencil sketches and drawings by design consultants). This was supplemented with information from catalogue filing content tables and secondary literature, and with interview data from technical artist Joy Cuff who produced Moon sets from February 1965 and recalls back-stage aspects of production and pre-production.

Table 4. Production companies consulted for food technology and equipment.

Equipment	Food Technology
US Army Natick Labs	Pepsi Cola,
Whirlpool Corp.	Continental Baking
Seabrook Farms	Campbell Soup Co.
	The Borden Company
	Dannon Milk Products
	American Home Foods
	Frito Lay Inc.
	International Salt Co.
	Landloakes
	Heinz Co.

The design process was charted as follows in a series of distinct steps: Kubrick produced a 100 page questionnaire for Clarke asking about routine and habitability aspects of the *Discovery* ('What will they eat and how?'). Clarke then described food requirements and handling in microgravity, for instance that "there was no need for any skill in cooking. Packets had merely to be opened and popped into the tiny automatic galley, which beeped for attention when the job was done" (Novel Script, p. 35). Kubrick then sketched first outlines in a personal notebook, followed by production notes that specified necessary research to be conducted in relation to extensive farming and food production technology. Based on this, the production team consulted different food technology and kitchen equipment firms, some of whom had already worked in a space context (Table 4). Concepts of possible dispensing systems were created by the product design consultancies Steven Stratt Design of New York and General Mills, taking into account the background information produced earlier. Props and sets of the dispensers and a galley were produced for the shoot. During production, food technician Anne Bromhead experimented with textures and colours, and while many different options were considered, the team decided for edible mash, apparently in order to convey a certain "blandness" (Cuff, 2010) in the context of an initially monotonous mission. Finally, contemporary Arne Jacobsen cutlery was added to the props.

VI. Discussion

The following discussion offers a preliminary impression of the sample, as the main aim of the research was to establish and describe it in terms of habitability. The intention was to evaluate in general the possible suitability and applicability of this particular body of reference, according to the main introductory questions of whether and how to make use of fictional space design in a real space design context.

Considering the potential of narrative scenarios to both highlight new product ideas and initiate critical debate on human activity and experience, there are several themes that could merit future investigation. The first three of them highlight design concepts (novel applications or re-designs of existing hardware) from the films that could be assessed for technical feasibility and psychological benefit in future feasibility studies, with reference to the current state of the art. The remaining three points describe design-relevant issues regarding human activity in view of long duration mission from a critical design perspective. Preceding this is a short discussion of the case study.

A. Case study

The case study gives a snapshot of how aspects of the design development process in *2001* unfolded in several distinct steps. This process compares well to consumer product development. It involved many of the aspects that a design consultancy would iterate, from initial exploration of user needs – incidentally, using a fictional technique of collaborative development of the novel through communication between the space expert (Clarke) and the informed space layman (Kubrick) – to visual research and review of state of the art, solicitation of subject matter advice of specialised companies, outsourced production of alternative system configurations or product morphologies, experimentation, to final styling and pairing with off-the-shelf products (in this case, cutlery). Aside from these steps, there were most certainly additional smaller iterations that could not be captured in this case study. Although this example is by no means representative for the design development process in the entire sample, it demonstrates

a level of thought and effort that is comparable to a non-fictional context, and an objective in responding to user needs that include both the theatre audience 'user' and authentic user in space.

B. Design Concepts

There were a number of interesting design points that could provide impulse or reference to feasibility studies in product development or re-design of real space systems.

Many of the films featured skylights, lightwalls and light-box style tables feature. This was in most cases due to create favourable lighting conditions for the set, but in an operational context could be of use to integrate artificial sources of daylight to support scheduling and circadian rhythm in deep-space missions where natural cues are scarce (Weinstein et al., 1967). Research on blue ambient lighting (ESA, 2009) and optimised light sources to support circadian rhythm (Fucci et al., 2005) is currently in progress. While lit-up walls void of clutter might be both pleasant and useful, the integration of large scale light aggregates might prove challenging in small spaces with little extra stowage, and heat and power constraints. However, with smart materials technologies evolving and low energy light emitting diodes (LED) lighting applied in extreme environment habitation contexts (Broughton, 2009), light emitting sources could be applied to surfaces of organised stowage, such as drawers in racks.

Another point related to interior surfaces were the many different configurations of surface patterns and decoration, such as embossings or cladding, although always in a single, mostly neutral tone. Combining meaningful visual complexity with functionality seemed to be a major point in many of them, by unifying functional components of the walls into organised patterns that in some cases were self-similarily varied in scale. The concept of functional aesthetics has been described by Clearwater & Coss (1991), and a case for investigating fractal proportions has been made for the interior of spacecraft by Kit & Howe (2003), Kriegh & Gardner (2002), and Wise (1988. Thus "disguising" functions or functional components, such as pipes or cables, could aid content management, retrieval and small-scale wayfinding. In addition to bar-code scanning currently used on space station, application of RFID technology has been highlighted as research area (NASA, 2010) and in combination with smart surfaces could enable novel retrieval concepts in a synchronised colour scheme.

Another point concerned plant growth capabilities. These have been integrated into all long-duration habitation from Salyut onwards and will no doubt play a fundamental operational and psychological role in future missions. The films feature many different typologies from experimental greenhouses to walk-in growth chambers, decorative plants and bioreactors. Of interest were some of the configuration options, notably when plants were included as part of an ecological closed life support system (ECLSS) and presented vital organic processes in transparent tubes, or when plant growth chambers or aquariums were used as room dividing elements. In how far this is viable and useful in an operational context remains to be assessed. But as organic life support systems are a growing critical area of research today (NASA, 2005; Poughon, 2009; Hendrickx, 2007), it could be interesting to evaluate the psychological acceptability of fully grown plants versus decomposing material in support of visual integration of the system into habitable volumes.

In addition to the above, unexpected in terms of design was *Moskva-Kassiopeya*, a Soviet TV series unknown to the authors prior to the study. It portrayed a number of innovative features in terms of design concepts, such as a device for research purposes that could only be compared to a 3D printer today, and a 'holodeck'. The holodeck – usually more familiar to the SF audience from *Star Trek* – was then picked up in a slightly more technically feasible, or at least explained, format (if not too spatially generous for a spacecraft) by *Sunshine*. There, a restorative 'Earth-room' was integrated into the medical suite, basically consisting of an immersive screen-panelled cube in which bespoke multi-sensory videoclips of Earthly scenes or events were displayed to the user inside the cube. A similar room was found in a medical environment in *Aliens* where a virtual natural hybrid environment was used for restorative purposes. This integration is comparable to contemporary 4D entertainment technology, where 3D footage and seat-motion are enhanced with additional sensory input, such as volatile fragrance compounds, smoke or foam. While comparable motion inside the spacecraft would present a vibration challenge, virtual environments for training, exercise and entertainment purposes have been highlighted as promising (Imhof, 2004), and devices for additional sensory input, such as small scale haptic technology, are technically feasible.

C. Design Issues

It was interesting to see that many of the films produced in close consultancy with space agencies did not actually offer novel design ideas, possibly due to the fact that they aimed at portraying relatively accurately a realistic near future or alternative present. Their depiction of the design aspects of human activity was relatively conventional, in essence replicating in high quality footage what is available in space agency video archives (exercising on treadmills, playing with sugar-coated chocolate balls in microgravity, personalising quarters with

mission patches, mottos and family photos). However, possibly through retaining a degree of liberty from the constraints of government agencies aware of public image, the film's critical reflection on informal, real human activity that would arguably entice a theatre audience, could be of more interest to the designer. Such they touched, albeit in a mostly serene or sterile manner, on issues such as self-brewed alcohol and formal use of drugs or medication, crew dynamics in gender-heterogenous crews, accident, sickness and death, crew creativity and spirituality, dynamics of on-board content management and system failure. These are all issues of interest to the space planner (Kanas & Manzey, 2003; Suedfeld & Steel, 2000; Stuster, 1986; Solodilova-Whiteley, 2007; IISTF, 2007). Other more independent films, including parodies, raised additional issues such as extremely low morale, psychosis, use of weapons and recreational drugs, organisational subversion and disobedience, amongst others. In particular, three areas stood out, including consumables, untidiness and personalisation, and DIY activities.

The development of leisurely consumables for special occasions, or ways for the safe consumption of these, could derive input from some of the scenarios of use shown in the films that depiced use of narcotics and alcohol, which featured prominently in the sample. Food was illustrated with great variation. Mostly, ingestible or inhalable supplies were shown beyond mere nutrition in connection to social occasions, reaction to boredom and, of course, medical intervention. Variations in content, form and dispensing of food – invariably linked to volume, mass and stowage constraints – will be crucial in long missions (Suedfeld & Steel, 2000; Stuster, 1986;). Another consumption point is linked to hygiene and personal care. Grooming, in particular among bearded (or subsequently shaven) men, was in many films portrayed as leisurely solitary or social activity. The use of a black paste for face decoration purposes of a male in one of the films, as well as the omnipresence of wedding bands, illustrate the possible need to discuss the role of cosmetics and jewellery as personalisation and individual care components on long missions. Considering the small size and weight of rings – that many astronauts wear – necklaces or the compactness of existing lipsticks, for instance, a great degree of individual satisfaction could be derived from a relatively small mass expenditure. In many of the films, the depiction of mundane objects, such as underwear, suggested a distinguished quality of the items. This will be due to the visual aspirations of the films or opportunities of product placement. In longer missions, however, the luxurious or valuable rendering of basics – aside from excellent performance – could, indeed, be of psychological value. In a setting that is acknowledged by astronauts to be very basic from a comfort perspective (Kanas & Manzey, 2003), high-end basic articles would reflect the ambitious and high-achieving nature of both space programme and crew-members. This is, of course, already reflected in hardware and items currently used on station, including accessories such as sunglasses and wrist-watches, but luxury commercial off-the-shelf products could move even more to the foreground here. Another surprising point in this context was the relatively frequent depiction of kimonos and dressing gowns. It could be of interest to investigate the need for, or acceptance of, this type of clothing at the threshold of private personal care and semi-private leisure time for a "shirt-sleeve environment" (Yamaguchi, 2000) in addition to exercise wear.

The managing of content that already presents a problem in reduced gravity conditions today (Allen et al., 2003) could add hazard to unpleasantness in much longer and isolated missions, where missing pieces cannot be replaced. Scenarios of use are visualised by various texts across the sample, from independent films to space agency-consulted. There, deterioration of order is either synonymous with decline in morale or high workload and the films offer a handful of scenarios that can form an impulse for psychological discussion. It could be interesting to assess the dynamics of untidiness in a microgravity context, in order to establish a base-line for monitoring whether untidy personal quarters are a visible marker of stress or depression, for instance.

Closely related to content management is the re- and 'para'-utilisation of onboard provisions for crew entertainment, systems maintenance and solitary occupation. Positive highlights that appeal to many scientist-astronauts and flight engineers today are personal DIY and science projects (Shayler & Burgess, 2007), and sustaining engagement in meaningful occupation on extended missions is critical (Cohen, 2001). Again, the sample delivers a multitude of examples of reconfiguration of existing onboard supplies for different occasions or applications, such as self-made birthday presents and Christmas trees. Two interesting cases combine DIY and personal care, where apparel and artificial hair are reconfigured or changed; one other case even showed animations possibly produced by the crew and used in variety shows not unlike those reported from early Antarctic exploration vessels to keep up morale (Stuster, 1986). This is personalisation of the environment beyond the mere pasting of pictures and notes. A facilitation of recycling that contributes to both personal edification and the upholding of the life-cycle of equipment on board could be a valuable design issue in future. Familiarity of equipment for in-situ modification has been highlighted as positive for onboard training (Aguzzi et al., 2008). The advent of portable 3D printers, as envisioned as early as 1973 in the sample, could offer additional scope.

All these issues have ethical, medical, operational and political implications and are the subject of debate among space planners already. Issues, such as sickness, death, substance use have been recorded anecdotally in space analogous settings (Stuster, 1986; Suedfeld, 2010) and will be of interest in the future. If they were to occur in an environment where crew autonomous behaviour is vital (Solodilova-Whiteley, 2007;), addressing these issues through design intervention can increase safety aspects.

VII. Conclusions & Recommendations for Further Research

In the context of the emerging field of design fiction in relation to scenario building and recent research connecting SF literary concepts with space systems development, this paper aimed at addressing a gap in the body of reference at the conceptual periphery of operational space architecture and design. To approach this nevertheless complex topic, emphasis in this study was placed on the systematic identification of a suitable set of references, and a comprehensive description of design concepts. It compiled a detailed inventory of environments, products and interactions of 30 cases of space habitation across an internationally broad set of moving image from the second half of the 20th century to date. A case study documented an isolated example in one of the industry's most acclaimed films. Findings indicated that there is rich design information to be elicited from the existing body of films, which can be grouped into conceptual design solutions and design issues more generally related to mundane or even subversive human activity. With this, the authors hope to add to the notion of validity of applying speculative design practice in a space systems development setting as complementary method to conventional scenario techniques.

To facilitate a more specific use of the design information presented, the limitations of this study in scope and method point towards further research and experimentation in terms of sampling, analysis and application of results. Before further analysis, the sample would benefit from augmentation. A reassessment by native-speakers and film historians should identify potentially suitable films not considered in this study, despite a rigorous sampling process. Historical data should be refined for each piece, such as detailed information on budgets, production time and, importantly in this context, the extent of scientific council for each film so a comparison with space design studies based on industry or academia can be made. Further, classification codes could be introduced to distinguish utopian, dystopian or parody productions (Slaughter, 1998) as well as key plot components or story-lines in order to establish more specifically the films' agendas. In terms of design, distinctions could be made between the invention of novel applications or concepts, re-design of existing hardware, or more abstract critical design engagement. Such a data-package could then be of interest to different stakeholders in space planning, and from a socio-historical perspective, i.e. regarding the mutual impact of SF design on the technology context in general, or vice versa, reflection of contemporary technology in film.

Using the existing body of reference, analysis could then plot SF designs against contemporary technology developments, and juxtapose design concepts with real concepts, as tentatively sketched in the discussion. From an operational space perspective, this juxtaposition could form a precursor study to the testing of selected concepts for real feasibility, isolated from a theatre context, mocked-up and tested against psychological and technical benchmarks under laboratory or analogous conditions. Detailed archive research, as implemented for one case in this study, will not be feasible for many of the films, as legacies and documentation are not always available. Historical case studies using anecdotal evidence and published interview accounts of directors, producers and designers could reconstruct the design processes in many of the films in order to provide a base for formal methodological comparison to other scenario building techniques.

Finally, for this method to be applied on a wide and more formal scale in a space systems development process, the data-mining of an existing sample can only be regarded as preliminary stepping stone. Although most of the films benefit from combined efforts of both space and design professionals, their expertise is segregated. Also, while this study indexed and structured existing scenarios, a prerequisite of meaningful analysis (Carroll, 1995), this effort was made retrospectively. The goal of the scenarios created by film production teams and space experts – however rich, novel, accurate or critical – was not to prioritise design objectives. To be truly effective in aiding design decisions for an eventual setting characterised by great uncertainty, a scenario must be based on some form of baseline data (Zeisel, 2006) and have clearly defined components and relations from the outset (Carroll, 1995). Both aspects were, in our sample, only intangibly embedded in the contemporary production agendas of the films and its space industry stakeholders. Hence, ideally, design studies using this particular format of fictional design should be systematically developed by individuals experienced both in the creative and aerospace disciplines, who ask pre-defined, specific questions relevant to the concrete mission scenario to be addressed in planning. Space architecture and design practitioners, in collaboration with psychologists, planners and system engineers, would appear to be particularly suitable to effectively and productively be conducting such a design exercise. Building fictional design narratives could result not only in meaningful design solutions for a long duration spaceflight setting, but also in more robust mission scenarios.

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