Synthetic Standards in Managing Health Lifecycles and Cyber Relationships

Simon Reay Atkinson
Complex Civil Systems Research Group
The University of Sydney
Sydney, Australia
simon.reayatkinson@sydney.edu.au

Amanda Goodger
Engineering Design Centre
The University of Cambridge
Cambridge, England
acg66@cam.ac.uk

Seyedamir Tavakoli Taba
Complex Civil Systems Research Group
The University of Sydney
Sydney, Australia
seyedamir.tavakolitabaezavareh@sydney.edu.au

Nicholas H.M. Caldwell
School of Business, Leadership and Enterprise,
University Campus Suffolk
Ipswich, England
n.caldwell@ucs.ac.uk

Liaquat Hossain
Information Management Division
Information and Technology Studies
The University of Hong Kong
lhossain@hku.hk

***Abstract*—This paper considers connected strands of thinking in the area of socio info techno systems emerging from Sydney University, Complex Civil Systems Group, the Advanced Research and Assessment Group (ARAG), Cambridge University, Engineering Design Centre, the Information Management Division at the University of Hong Kong and the School of Business, Leadership and Enterprise at University Campus Suffolk. The paper is divided into six sections. First, it examines the synthesis of the machine and the organization in what has been termed mechorganics; then, it identifies the Lodestone concept as a means for instrumenting social awareness; before considering the role variety plays in collaboratively influencing complex systems, over time, and coordinating and controlling them, in time. Having established the bases, the paper then develops a lifecycle model applied, in this instance, to the health sector. Finally, it examines the needs for assaying information and data as a means of providing the social transparencies needed for real time verification and validation. From this, it posits the needs for simple empirical standards and setting/vetting organizations that encourage good behavior and discourage bad. These standards' organizations provide for the governance and assurances necessary for packet-markets to form where transactions / prices can be assured, products verified, exchanges made and fees / taxes abstracted.**

Keywords-mechorganics; lodestone; instrumenting; packet-markets; governance; metadetics; synthetic ecology; assaying.

I. INTRODUCTION

This paper is developed from a paper presented at SOTICS 2013 entitled The Need for Synthetic Standards in Managing Cyber Relationships [1]. In this paper, we consider Cyber may consist of two sub-systems identified and classified as being **"**Coordination Rule and Control (CRC)" and "Collaboration and Social Influence (CSI)" [2, 3]. These system attributes provide the necessary and "requisite variety" [4] to enable both control, "in time", and influence [5]-[9], "over time". In this regard, Cyber may consist of two poles:

> A technologically bounded, largely immeasurable, strongly scientific, stochastic *coordination*, *rule* and *control* space; comprising virtual-media and the display of data dealing with the *real* communication of *facts*; and the *conceptualization* of alternative possibilities, themselves capable of generating hard physical and soft more *social* effects and *collaboratively influencing* them [10].

"Mechorganics" is postulated to have 1) a thematic *systems* identity (defined by its *networked* disciplines) and 2) a *critical* and *functional* education base [11,12]. It is not seen either as 'a reversion of digital data back to an analogue form' [13] or some form of 'Golem' warned of by Wiener [14]. Mechorganics is based on "designing humanity back into the loop" [15,16] and: 'the *synergistic* combination of *civil* mechanical *systems* engineering, social network dynamics, ICT and the management of *interconnected* knowledge, information (and data) *infrastructures* in the *designing* and *composing* of *adaptive* (resilient and sustainable) organizations' [15].

The "Lodestone" concept arose from a concern that the "Cyber-pole" applying Coordination, Rule and Control (CRC) was being emphasized at the expense of the whole and specifically the pole dealing with collaboration and social influence. The result, it was conjectured, was twofold: first, that government was becoming irrelevant to many social-media users and, secondly, that this was creating a vacuum in which less benign influences might flourish. For example, studies of social networking and identity have shown that there is a strong tendency to connect like-to-like [17]. This narrowing focus potentially reduces societal *variety* and makes people less tolerant to alternative ideas and *ontologies* than their 'non-digital forebears'. They may, in actual fact, become non-democratic, *xenonetworks* (from xenophobia, xenonetworks are 'social networks with a strong dislike or fear of other networks or ideas that appears foreign or strange to them') [3], extremely hostile to alternative ideas (and that they might be wrong). Discussion at the time was focused (as it remains largely today) on finding information 'keystones', 'architectures', 'protocols' or 'gateways' not so much to assist people identify good information from bad but to control. A problem with each of these concepts is that they obtrusively and exclusively focus on the stable, static (hence keystone) and ergodic, as opposed to the dynamic and non-ergodic. The "Information Lodestone" concept recalled the semi-mythical lodestones of antiquity that enabled ancient mariners both to determine / 'fix' their position and simultaneously steer a safe course. The objective is to design a non-obtrusive, dynamic instrument. In this respect, we are commencing work with Health and manufacturers of sensitive materials, to model and identify data / information flows and the potential for leaks along complicated, sensitive lines-of-communication in which knowledge assurances, e.g., for operating on patients, are essential. Other work is being undertaken to teach life systems management skills to young people, with an emphasis on either *metamatics* (the mathematics of cyber-social and cyber-physical systems) or *metadetics*, as defined in this paper. We consider this to be exciting work, on the cutting edge of our science, essential to enabling the emerging Knowledge Enterprise Economies of the 21st Century.

This paper is divided into six sections. In Section II, the cyber-system is considered as it relates to the individual and at the social level. In the next section, means for instrumenting the Cyber are posited from which we then posit the types of setting and standards that might apply. This is then used as the bases for modeling a health life system as applied to the Australian Radiologist profession. Finally, inclusive designs and *standards* to enable people to *sensemake* within new and emerging cyber and synthetic ecologies are posited.

II. CYBER AS A SOCIAL BEING

The informal motto of the Lodestone Project was suggested as 'conscius in res' or "sense-in-being", relating to Badiou's [18] understanding of "being", when he states: 'what happens in art, in science, in true (rare) politics, and in love (if it exists), is the coming to light of an indiscernible of the times, which, as such, is neither a known or recognized multiple, nor an ineffable singularity, but that which detains in its *multiple-being* all the common traits of the collective in question: in this sense, it is the *truth* of the *collective's being*'. The idea of *multiple-beings* holds within it the traits of the social being at the heart of most systems and organizations. It is their truths and trusts that "detain the common traits of the collective in question". When these trusts dissipate or are allowed to wither, the organization may remain as a physical entity (when a building becomes statue) but its essence and being – its "ineffable singularity" – is no longer [19]. It is conjectured that, by dealing with cyber exclusively as an info-techno construct, many organizations lost sight of their "social being".

Considering the Cyber as two poles, it is suggested that one has more info/techno-socio traits; the other more socio-info/techno, in which, building on work by Harmaakorpi et al. [20], [17], it is posited that: 'Info-Techno-Socio systems seek to program (as opposed to programme) the relationship between technical *processes* and humans by *digitizing performance fidelity* and coding for repeatable *risk free* procedures in computer-control-spaces so that *data* and *communication* do not [temporally] contradict each other ' [21]. By contrast: 'Socio-Info-Techno systems stress the *reciprocal interrelationship* between humans and computers to foster *improved shared awareness* for *agilely* shaping the *social programmes of work*, in such a way that *humanity* and *ICT [control] programs* do not contradict each other '[21].

The two systems are also considered in terms of their signatures, where I-T-S systems are considered as strong-signal systems [22]-[25], in which: '*Control* (through *switching*) of Information, Data and Communication are the key variables' after, Castells [26] and Sokol [27]. And weak-signal S-I-T systems [22]-[25], in which: 'Influence (through *shared awareness*) of Information and abstracted social Knowledge are the key variables', after Castells [26].

Most of us intuitively know the type of organization we would wish to be working for. Warren and Warren (1977) considered this in terms of "organizational health" and concluded that 'healthy organizations' have 'a critical capacity for solving problems', [28]. They identified three dimensions of *connectedness* (see also Thibaut and Kelley [29]): *identification* with the organization (they referred to as neighborhood); interstitial *interaction* within the organization and existential *linkages* outside the organization.

Considerations of health apply equally to organizations working with/in the Cyber and their capacity for "problem solving" and so controlling, in time, and influencing, over time. This research is developed further in Section V. It is contended that successful companies are constantly "balancing" between the *exploitative* (delivered *in time* by coordination, rule and control) and the *explorative* (delivered *over time* through collaborative social influence). The capacity for balancing between coordination & control (the exploitative) and collaboration and influence (the explorative) to keep an organization "in kilter" is known as "ambidexterity" [30]. It is suggested that this ability to *dynamically balance* between the *exploitative* and the *explorative* is indicative of a systems ability to "problem solve" and, therefore, of its health.

As humans learn, it is thought that they develop a critical capacity for problem solving based upon their individual social system model. This capacity for systems and critical thinking can be taught and is seen as a necessary pre-requisite for understanding and dealing with complexity. In this regard, from Lever et al. [31], it is considered that:

> **Systems Thinking** may be the ability to determine appropriate options for leading, managing, designing, engineering and modeling complex systems, taking adequate *empirical* account of different system types, configurations, dynamics and constraints, and
>
> **Critical Thinking** may be the ability to ask the right questions and make useful sense of information that is technically complex, incomplete, contradictory, uncertain, changing, *non-ergodic* and subject to competing claims and interests.

After Dreyfus & Dreyfus [32], it is suggested we all have an individual 'meta-datum' that *reference* what is posited as our "metadetic spheroid" [32]-[34]. This gives rise to concepts of "metadetic-datum", with similarities to a geodetic datum used to "reference" the spheroidal model of the earth being applied, e.g., World Geodetic System (WGS) 84. Individual metadetic spheroids may be broadly similar. How they are referenced – in other words their datum – is seen to affect how humans' process information and what they perceive. A metadetic-spheroid is an individual's model (no matter how incomplete) of the sociodetic-spheroidal "beings" / organizations they inhabit; see Fig. 1. The meta-datum achieves the best "fit" of an individual's metadetic-spheroid to what may be thought of as its "sociodetic-spheroid" describing the overall model of the related social system.

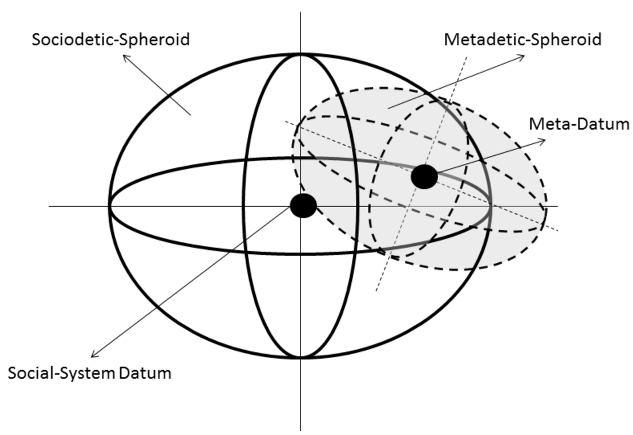

Figure 1. Sociodetic / Metadetic Spheroids and Datums

Bunge [35] maintains that 'perception is personal; whereas knowledge is social'. An individual's perception of their "sociodetic spheroidal system" is incomplete. Only by "collaboratively connecting" with "others" metadetic spheroids may an individual begin to "map" the sociodetic spheroidal whole. It is this process of "collaborative sensemaking" that moves what is effectively static, positional information and data to the social and dynamical knowledge of "being".

Markov chains applied within Bayesian Belief Networks [36] were considered by Logan and Moreno [37] in terms of 'Meta-State-Vectors' referenced to 'Meta-Data' [32]-[34]. Meta-State-Vectors (MSVs) relate to the idea of some information containing "indicators" that will be identified immediately against an individual's metadetic-datum without the need for preamble / additional processing. MSVs are therefore distinguishable from serial information; from which 'expert' human processors 'can form diagnostic hypotheses and draw rational conclusions from system patterns [and] *critical* reflection of their own meta-datum' [32]. In terms of collaboration and shared awareness, this should enable individuals to 'make better use of one another's expertise' [39], particularly if 'authenticated' [39], validated and verified.

In a social system, there also exists the risk of knowledge blindness or "blind knowledge" [40,41]. Models of "info/techno-socio exchange" and "socio-info/techno knowledge capture" therefore need to differentiate 'between the active physical and technological capture of data and information' [42, 43] and the socio-info/techno exchange of knowledge [44]-[49]. To understand how the best "fit" is to be achieved between the info/techno-socio "machine" and the socio-info/techno organizational "being", it is necessary to identify the system's ecology and its purpose / role within it. If an organization's purpose is to problem solve, then how it maps its sociodetic spheroid and positions its datum will determine its health and future fitness judged by its ability to 'test for both success and failure' [50].

III. Instrumenting the Cyber

At the turn of the millennium, the old UK Defence Research Agency (DERA) was undertaking trials of networked soldiers at the British Army Training Unit in Suffield (BATUS), Canada. Soldiers had all been issued with GPS. As reported to the first author, the result was "digital" in terms of the troops' movement, which was recorded as being "stop and go". Troops would stop, find out where they were, report their position and then move. The researcher removed GPS from the soldiers and caused them to return to map and compass. The result was dramatic. Soldiers began to interpret their datum against the map and to use their senses to determine progress. They used the compass to provide analogue direction and their bearing to dynamically align their datum.

After the Heisenberg principle, Price [51] suggests that 'it is impossible to determine simultaneously both the position and momentum of a particle with any great degree of accuracy or certainty'. This led the first author to surmise a potential metaphor for the modern age: 'that we *know* precisely where we are but we no longer *know* where we are going'. Although causality is hard to attribute [52], it may be possible to apply the Heisenberg principle as a useful rule-of-thumb when designing dynamic (non-ergodic) systems by suggesting that:

> 'the more precisely one measures a position, the less able one may *identify* change, over time, and vice versa' [19].

This has specific implications for system designs noting the predilection in recent years to emphasize metrication and the setting of targets / goals etc. for managing organizations. Reported separately [19],[53], instead of improving shared awareness, the excess of information and targets required as a form of control can detract from work [54] and so collaboration and shared awareness. This suggested that reducing collaborative and shared awareness impacts negatively an organization's ability to problem solve. *Ipso facto*, these *exploitative* type organizations become unhealthy and potentially, even, risky places to be.

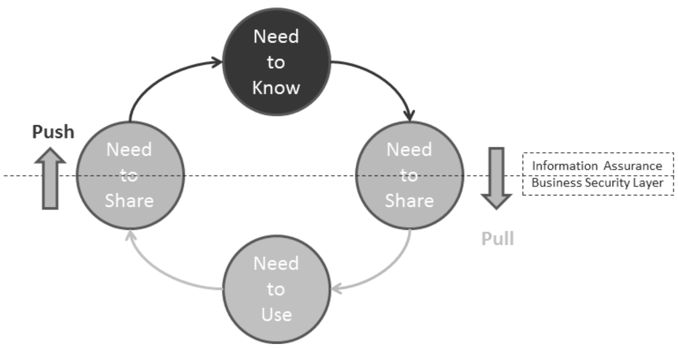

Figure 2. Three Needs Model (3NM)

In addressing the failures of government and collective (collegial) intelligence prior to 9/11 and the Iraq War, the US 9/11 Commission [55] and the (Lord) Butler Enquiry [56] in the UK identified the failure of governance specifically in terms of the *digital ecologies*, then in existence. What they saw was that essential information existed, but that it was being missed, mislaid and, critically, not *shared*. Furthermore, they saw confusion between data, information and communication networks (essentially ICT) and what was being identified and abstracted in terms of *knowledge* and actionable intelligence that could be appropriately *shared* and *used* across government, in real time. Busy Secretary's of State, Ministers, government officials / business / industry / financial leaders and project / programme directors, managers, administrators, users, agents and other consumers of *actionable intelligence* were being overwhelmed in a deluge of data and information technology, process and methodology that was quite literally *blinding them* to what was vital; what was strategic; what was operational; what was routine; what was base level knowledge (against which change and perturbations might 'show up' (be *envisioned*)) and what was simply background *noise*. Organizational structures had not simply atrophied but had become 'tuned out' – no longer able to select between the vital *weak-signals* of innovation, adaptation and change (as threat or opportunity) and the *strong-signals* of method and process [22]-[24],[57],[58]. Recommendations arising from 9/11 [55,56] and the Global Financial Crisis were three fold: firstly has been to require greater transparency, e.g., between the banks, investors, borrowers and governments; secondly, has been to demand greater regulation and thirdly, to move away from the need to know control model towards what has been described as the three needs model – need to know; need-to-share; need-to-use (3NM) [43].

Knowledge blindness [41] was also seen in the run-up to the Global Financial Crisis (GFC), when public and private organizations / individuals capable of identifying alternative *futures* were no longer able to communicate / be listened to: 'It is remarkable that the advanced research and assessment group…put the danger of a global financial collapse into the [UK] draft national security strategy [in 2005/6], but were told to take it out, presumably for political reasons, before it occurred' [59].

In this respect, Szilard's warning that 'information is expensive to acquire and use' [60] and Bunge's recognition that 'knowledge is social' [35] had been potentially lost in the *noise* of new IT, methods and processes. The Lodestone project was conceived from this confusion and a recognition that 'today's economy and society is totally reliant on technology as an enabling force for all economic and societal activities' [61]. It identified the potential of societal cascades in which 'a failure of a very small fraction of nodes in one network may lead to the complete fragmentation of a system of several interdependent networks' [62].

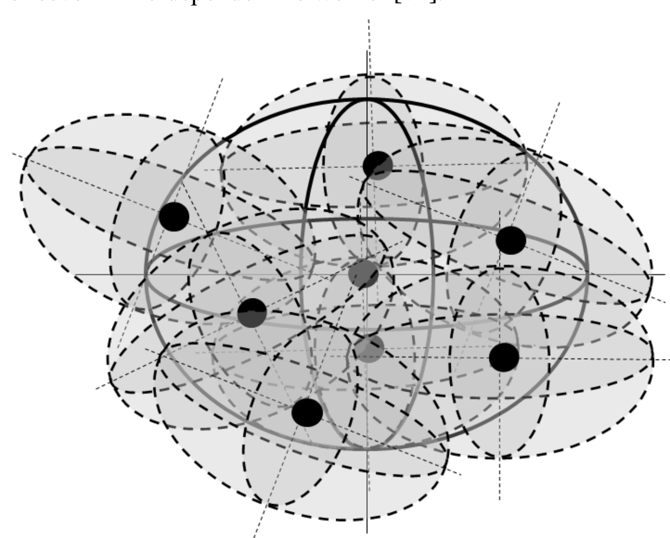

Figure 3. Multiple Meshed Sociodetic / Organisational System Model

The series of cascades considered at the time (2009/10) included UK strategic failure in Iraq and Afghanistan [63] and the global financial crisis. Significantly, an undermining in binding societal trusts and assurances were seen simultaneously to be occurring / had the potential to occur, such as the UK MPs honors and expenses scandals; connecting to the phone hacking scandal that implicated media, police and politicians; to the failure of the BBC to protect young and vulnerable people; to the 2010 UK student riots and the 2011 "London" riots. Each of these cascades began / was exacerbated in the Cyber as, potentially, they will also be resolved. Consequently, it was seen as being necessary 'to protect…information infrastructure technologies…a strategic core [of] which must be maintained, i.e., the Critical National Infrastructure (CNI) / Critical Information Infrastructure (CII)'.

It was recognized that 'small incremental changes and / or large-scale modifications can drastically shape and reshape both the economy and its society with known and often unknown consequences, due to ever-increasing interconnectivities and growing complexities … especially, the information technologies that have come to pervade virtually all aspects of life' [64] – hence "societal cascades". This led to the development of an 'Assurance Case Approach methodology for individual CII assets to input into the larger Business Information Environment', 'the development of a *Mesh* case that can be visualized as the 3-D atomic structure of a molecule' and which 'provides a lateral approach for interdependencies between individual assurance cases' [61]. The "multiple" mesh envisioned represents the sociodetic spheroidal "being" described by Fig. 3 and relates to both interdependencies and assurances to provide overarching confidence in the system whole. Protecting the system whole and providing for resilience and responsiveness required a flexible, adaptive and *ambidextrous* CSI 'approach over time and real-time', CRC mechanisms for interacting directly with 'dynamic information ecosystems' [61], in time.

IV. SETTING CYBER STANDARDS

Regulations and controls can be antithetical to creating a shared aware and collaborative ecology and enabling the necessary transparencies for encouraging good behavior and discouraging bad [53]. The three needs model aims to create an information assurance / business security layer between the user (pull) and the knowledge (push) custodian [43], see Fig. 2. There are significant challenges to the managing of information and data allowing for successful, inclusive means for identifying / testing when information and data has been tampered with, changed, added to or where leakage points may occur. Examples include the loss (probably through accounting errors and multiple packet switching) of sensitive materials, e.g., in the explosives industry for products that have to be accounted for to the milligram. Similarly, limited information and data tracking (including asset tracking), e.g., in the health service, means that safety critical equipment can become mislaid or misapplied; so placing patients at risk. During the recent Europe-wide meat scandal an inability to track information and data and test / verify it for validity at key stages of the supply chain, enabled graft and fraud to take place across the whole.

Throughout history, successful economies have been based upon the accurate and reliable "assaying" of materials, such as metals (gold) and food. These social transfer points also became the opportunity for reliable trade and pricing moments and so taxation. Scales and weights were regularly tested and subject to daily public scrutiny – they created *transparencies* for encouraging good behavior and identifying bad. Similar open-social "assaying standards" that can be used to assess information and data in terms of its goodness, purity and proof are harder to find. And there is not a simple and readily available *instrument* such as a "scale and weights" or "map and compass" that can be applied unobtrusively at different stages of often complex supply chains to verify and validate information & data flows and leakages. This does four things: it limits transparencies; so encouraging graft / crime; consequently reducing the opportunities for legitimate business / taxation and discouraging good behavior.

In his theory of the firm, Coase [65] argues that the reason for firms forming is to enable 'employer and employee relations with regard to cost', which 'were necessary to understanding the working of firms and organizations'. He suggested that 'governance is chosen in a cost effective degree to infuse order, thereby to mitigate conflict and realize mutual gain' [65]. It follows that regulations and controls that fail to 'mitigate conflict and realize mutual [collaborative] gain' create unhealthy ecologies by limiting organizational problem solving capacities [53]. In his Law of Requisite Variety, Ashby [4] maintains that 'only variety can *control* variety' and that 'for every control one needs a controller'. Reported separately [19],[53],[66], 'organizations under control, may never be more shared aware than the sum of their links'. By contrast, organizations that enable collaborative social influence can 'generate, on average, 12.5% more [linkages] than formally specified' [19]. Furthermore, these organizations can adapt, over time, to different levels of control. In other words, these 'new' linkages also provide the 'variety necessary to *control* variety' – so meeting Ashby's Law of Requisite Variety.

V. A SOCIODETIC HEALTH LIFE-SYSTEM

Law & Callon state that 'the *technical* thus is *social*' [67]. Not only may the technological be social but, as previously noted, Bunge [35] attests, '*knowledge* is social' also. A key conclusion to be drawn from this is that *mechorganic* designs that consider the social as technical and remove from the technical its social knowledge, strip from an organization its heart and very 'being' [18],[68] – hence knowledge stripping [21].

Given its highly socialized technical setting, the Radiology specialization was identified as being an early indicator – a *canary* – for the "health" of the medical profession [69]-[71]. Representing approximately 6% of graduating medical students in Australia, the 12 year education programme (from commencing medical studies) is one of the longest specialist professional pipelines [72]. Compared to a graduate employee, radiologists spend three times as long in Higher Education, Table I, and for every year in education; 1.2 years working. Given these constraints, the profession may be highly susceptible to minor changes in recruiting and retention flows. It is also possible that a 6% radiologist-extraction rate (from medical schools / universities) represents a long term constant. In which case, based on US Figures [73], for every extra radiologist an additional 20 medical students (allowing for drop-outs) would need to start at Medical School – but such a simple measure may not reflect those medical students actually wanting / desiring to become radiologists.

TABLE I. HIGHER EDUCATION WORKING PARAMETERS

	Educ-ation (E)	Higher Educ-ation (HE)	Work-ing Life (WL)	E: WL %	HE: WL %
Graduate	17yrs	4yrs	43yrs	40%	9%
Medical	20yrs	7yrs	40yrs	50%	18%
Radiol-ogist	25yrs	12yrs	35yrs	71%	34%

A question asked of the profession was that of its *sociodetic* 'face' in terms of its profile and age. In other words, 'what is the face of the Australian Radiology profession today and what does the profession think it should be?' Noting the sensitivity of the profession to changes in its supply pipeline, another question may be 'what is a sustainable professional age profile?' From the RANZCR Radiology Workforce Report [72], it was possible to model the Radiologist Age Profiles for 2000, when the 35-44 year age group was the largest, compared to 45-54 years in 2010, when the average age was 50.7 (median, 48 years) [72].

Figure 4 considers three faces: the 2010 profile (average age 50); the 2021 population allowing for the ageing of the Baby Boomer / X Generations (~ 1945-1959 / 1960-1974 [74]) with the same numbers as 2010 and, thirdly, allowing for population growth to two thousand (2062) active radiologists based on the same profile. In the first instance, the 2021 profiles show the radiologist 'face' continuing to grey – from 50 to 53. The impact of an ageing tail on opportunities at the start-of-career is significant, which may act unintentionally as a position / job blocker in later years. New positions reduce from about 90 in 2000; to 80 in 2010 and 70 in 2021. Only by growing and changing the population profile to two thousand in 2021 (through a targeted *re-aggregation* program), do start-of-career opportunities increase significantly (to ~125 places compared to between 75 today and 100 in 2021, based on ageing the current population), while the average age or face of the profession reduces to 45 [72].

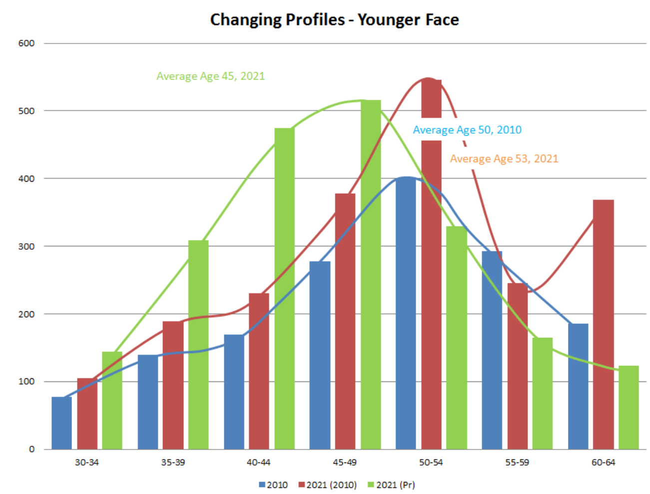

Figure 4. Radiologist New Age / Face Profiles 2010 & 2021

A complex system necessarily manages both growth and decline and 'hunts' for its equilibria positions. Nevertheless, it cannot always grow in order to sustain vacancies and opportunities at start-of-career. This may indicate that the current *sociodetic* model may be inherently unstable and potentially unsustainable (either interstitially or existentially) over the longer term.

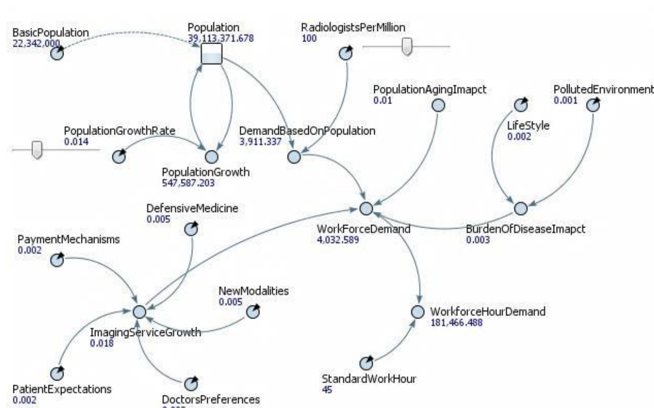

Figure 5. Demand for Radiologists in Working Hours, 2050

Based upon changing Australian demographics to 2050, a *sociodetic* study was undertaken and a *synthetic ecology* model of the profession developed [19],[71]. In this respect, we humbly propose a *Synthetic Ecology* to be:

'A system (being or entity) that *adapts*, over time, by combining, through design and by natural processes, two or more *dynamically* interacting networks, including *organisms*, the communities they make up, and the non-living (physical and technological) *mechanical* components of their environment'.

Continuing with the *sociodetic* examination of the Radiologist workforce, a number of factors were considered, including feminization linked to increases in part-time working (more notably amongst female practitioners); reducing working ages and population growth and ageing [72]. On feminization, much research over the last decade [75]-[79] has examined this significant trend in medicine. In this regard, after Douglas [80], Ferguson [81] and Fondas [82], Feminization is considered to be:

'the spread of socio traits or qualities that are traditionally associated with females to things (e.g., technologies) or people (professions) not usually [/ previously] described that way; including the shift in gender roles towards a focus upon the feminine, as opposed to the *pre-modern* cultural focus on masculinity' [71].

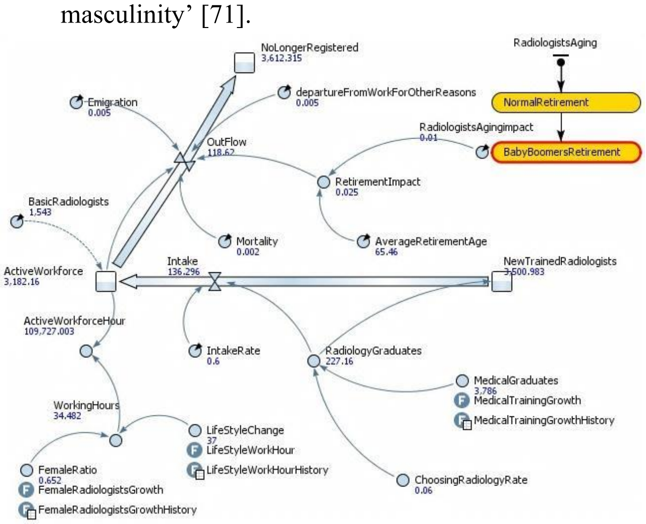

Figure 6. Supply of Radiologists in Working Hours, 2050

Feminization of the medical workforce appears to be a global trend [83]. The 2010 RANZCR Radiology Workforce Report [72] shows that females were 17.1% of radiologists in 1998; 23.6% in 2010 and anticipated to be 34% in 2020. Based on historical data, a function of the *sociodetic* model was designed to consider the future growth of female radiologists reaching a maximum of 65% female by 2050, based upon current European trends. This may have a significant impact on the system impacting, as it does, on the face and age of the population. On average, the working life of a female doctor may be 60% that of male doctors [84]. We hasten to add that we see *feminization* as a good - and one that we need to understand if we are to better *fit* our people to the *sociodetic* systems they work within. There is also an impact upon part time working, in that – quite unexceptionally – 17.3% of Australian female radiologists may be working part-time; compared with 6.7% of male employees [72].

The trend toward reduced working hours is also increasing among Australian radiologists. Studies show in 2010, 34 per cent (c.f. 20 per cent in 2000) planned to decrease their working hours, while only 8.7 per cent (16 per cent in 2000) planned to increase their hours [72]. The function in the *sociodetic* model expects the working hours in the future to be based on a dynamic full-time working profile (that assesses 37 hours per week as a minimum full-time equivalent).

Population growth and ageing is also likely to place potentially extraordinary demands on health services [71]. Changes to the workforce may also have the same demographic impact. The Australian Bureau of Statistics quoted by RANZCR [72] estimates that the 'Australia's civilian labor force aged 15 and over [will] grow to 10.8 million in 2016, an increase of 1.5 million or 16% from the 1998 labor force of 9.3 million'. Yet, the 'average annual growth rate of 0.8% between 1998 and 2016' is less than half that for 1979 to 1998.

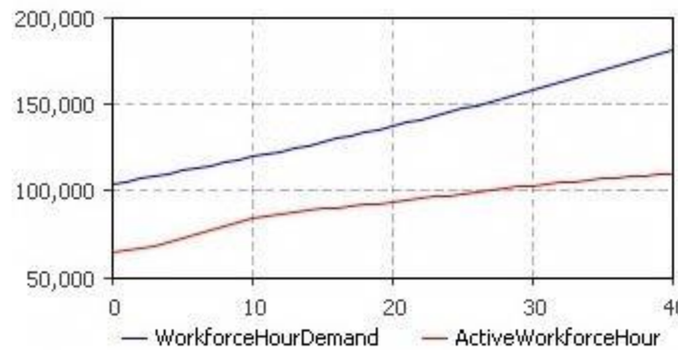

Figure 7. Radiologists Working Hours Demand and Supply (2010-2050)

Figure 7 shows the demand and supply of radiologists in a dynamic model over 40 years between 2010 and 2050. It appears that even if the radiology training programme grows at a higher rate (above the medical training growth rate) than its historical growth rate, the system would never be able to meet demand. It suggests that the 6% intake rate of first year registrars is insufficient and industry absorption will need to grow at a higher rate than the radiology specialist training programme. If the system is not able to increase the intake rate faster than the new radiologists supply rate (coming from the national training programmes and immigration) the profession may face two crises. First, supply and demand at current rates will never balance, Figure 7. Secondly, the number of trained, qualified radiologists who fail to enter the profession through the supply pipeline (un-employment in the occupation) may account for more than 3500 specialists over 40 years. Figure 7 indicates that the difference between demand and supply in active working hours is not simply about increasing the numbers of radiologists. The effects of factors such as feminization and lifestyle changes become more evident. A side-effect (pressure on active radiologists to become more efficient (more for less)) of this imbalance may result in the reduction of imaging services quality – a potential 'third crisis'.

Technological advances in medical imaging have been one of the key factors in the expansion of radiological examinations and procedures since the 1970s. Recent research [71] has shown that rather than necessarily acting as an *aid* to knowledge transfer between GPs, Radiographers and Radiologists that, while the amount of information transfer (20 times as many digitized images compared to old 'films') has increased, the all-important opportunities for collaboration between practitioners and patients (necessary for social knowledge transfer) has potentially reduced. Indeed, radiologists, nurses and radiographers meet to transfer notes, today, far less frequently – and the *weak* signals of 'influence and abstracted social Knowledge' are often lost / drowned out by *strong-signals* of information / data transfers. It was concluded that 'new technologies can result in more efficient productivity (measured by information transfer) but that they can also carry risk if incorrectly applied' [71].

Research identified that Australia, like many other developed countries, e.g., the US and Germany, is facing a dénouement: traditional models of health care, specifically in radiology, are unsustainable based on growing demand for health care services [72]. As a result of unique, interstitial demands on the Australian health system, it is suggested that the existing radiology provisions model needs to consider the *sociodetic* development of patient care, patient safety and quality of service in addition to increasing the number of radiologists and radiographers and changing information communication technologies – the socio-info-techno and the info-techno-socio [71].

Conventional responses in Australia and many developed countries have been to increase the number of radiologists. Since 2007, medical radiation science programs expanded and offered more places at universities. Although students with high entrance scores enter the Australian undergraduate medical imaging programs, it appears that significant numbers retire / leave the profession soon after graduation. This *leakage* may be partly due to the lack of clinically-oriented career development opportunities [85]. The other reason for leakage might be the oversupply of radiographers into the current employment model and its inability to use them appropriately, see Figure 4. The successful implementation of this concept – authorizing diagnostic radiographers to take new practice roles beyond traditional ones – was noted. Caution was also suggested – at the unit and operational level this may offer potentially attractive opportunities for optimization and fractionation as a way of reducing costs by reducing skill contribution and, thereby, investment in the individual [86]. At the system level, this type of 'Just-in-Time' [87] approach can cause problems to the development of skill sets 'over-time' – particularly in a tightly coupled system such as exists between radiographers and radiologists [72].

The appropriate application of part time workers, if managed at the system level, could enable the necessary flows into and out of the profession, while maintaining on-entry positions and the generation of expertise and experts later in the profession. Fragmented and fractionated [88] as the profession may have been managed to date, the projected increase in Part Time workers may negatively impact these positions through 'job-blocking' and reducing the all-important flows into, out of and through the profession [72].

Another tightly coupled relationship is that between the private and the public sectors. By and large, the private sector is interested in recruiting with established proficiency [89], such as radiologists with ten or more years' experience in the field. This can put pressure on employed numbers in the public sector – so creating a vicious circle of reducing numbers; increasing costs to the private sector and reducing levels of in-house expertise.

To increase *sociodetic* / system level performance in various clinical departments, *ecological* identification and classification of 'patients' characteristics' and available technologies may as well be necessary, specifically in 'redesigning scheduling schemes' [90]-[92]. After Walter [93] and Huang and Marcak [94], it is suggested that patient classification in a hospital radiology department may help to improve patient access to care. This may then enable the optimizing of medical resource utilization of socio-info-techno applications by better balancing the time of available doctors and specialists with patients [71].

VI. A New Metadetic

In this paper, we undertook an *ecological identification* (as opposed to system identification) of the Radiologist Profession. We did this in order to develop the *synthetic ecology* in which the highly socialized, technical setting of the radiology profession exists, today. To undertake the *ecological* modelling, we constructed a *sociodetic* model of the profession based upon the age of the profession and the factors affecting its previous, current and future supply and demand. We then used these '*dynamically* interacting networks' to construct and test models of the profession as it may vary (depending on supply and demand inputs), over time. In undertaking this research, we suggested what a *Synthetic Ecology* might 'be'. Given its early application of ICT imaging and data / information management technologies, we saw the Radiologist profession as increasingly operating within the Cyber. This poses challenges if the profession is to: retain knowledge; learn, over time; respond to relatively rapid changes in supply and demand; while preserving quality of health care provision. We identified that the current model was failing and that, unless change was addressed at the socio-info-techno system level, the profession would fail to meet projected population demands. We concluded that new *inclusive* standards were required in managing health care provision and relationships – specifically between specialists, practitioners, patients and new technologies – that will, increasingly occur, *exclusively* within the Cyber.

In setting Cyber Standards, the issue appears two fold. First, to create inclusive standards through 'the *synergistic* combination of *civil* mechanical *systems* and the management of *interconnected* knowledge, information (and data) *infrastructures* in the *designing* and *composing* of *adaptive* (resilient and sustainable) organizations' [15], that readily encourage openness and transparencies and can be easily *assayed*. Secondly, is for these standards to encourage collaborative shared awareness, from which new controls and pricing opportunities and markets may emerge. Thus, inclusive standards for information / data "packet-switching" may create opportunities for "packet-marketing" and so for pricing and taxation. This returns to *standards* acting as social *instruments* that, through their very "being", can *synthesize* the info-techno and socio to create opportunities both for collaborative *exploration* and *exploitative* control – or *ambidexterity*. It is posited that creating socially inclusive and acceptable *standards* for *assaying* the goodness of information and data enables this *synthesis*. This leads potentially into a third area to do with the synthesizing of Cyber Standards, introduced in Section III and by Figs. 1 and 3 and to a concept for Synthetic Ecologies introduced in Section V. Finally, applying the *sociodetic* model developed for the Australian Radiologist profession, it is suggested that how social reference-standards are designed to be inclusive of the machine and the organization and are best "fitted" to their organizational (*sociodetic*) systems, may potentially be considered as the subject of "metadetics".

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