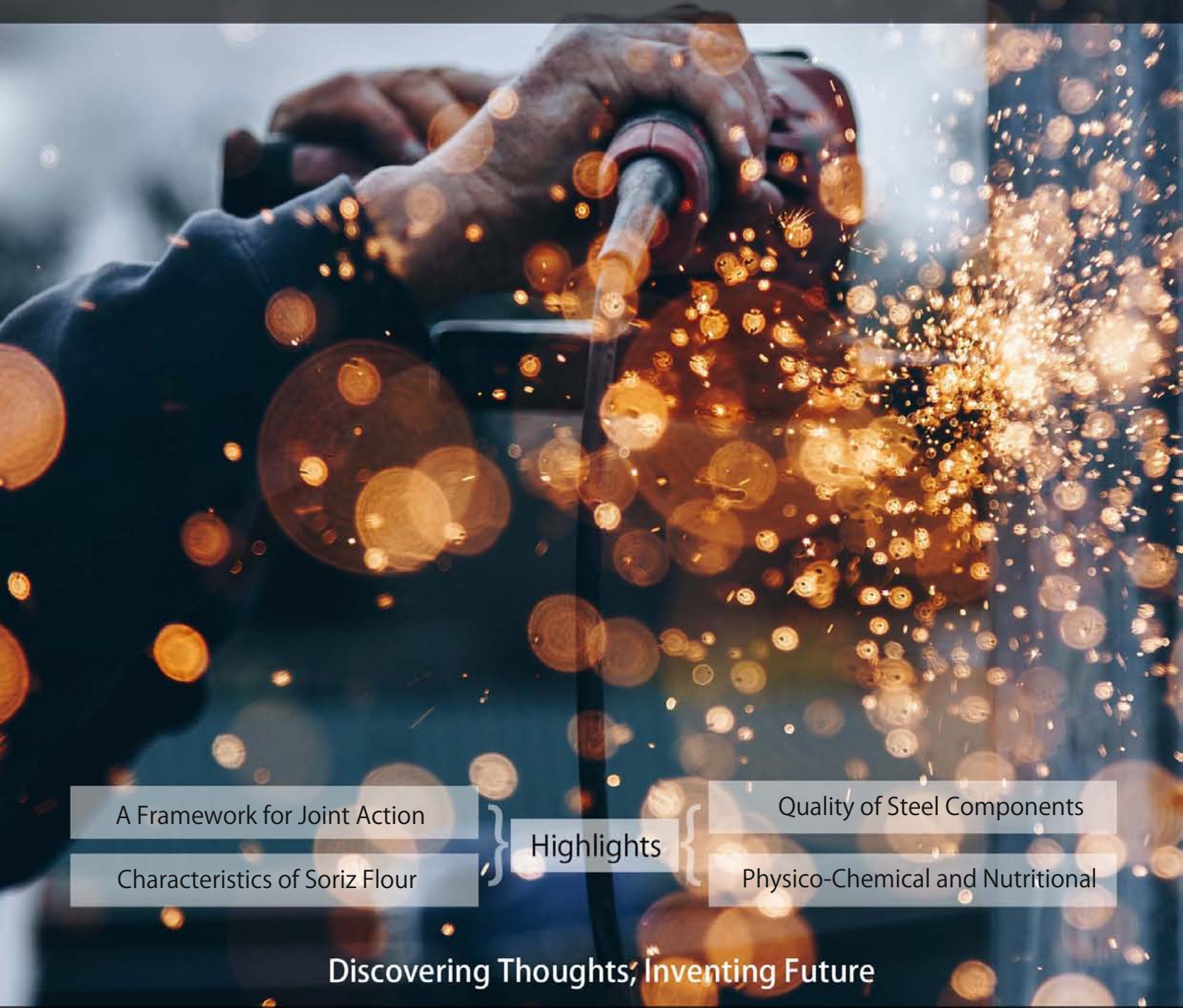


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Physico-Chemical and Nutritional Characteristics of Soriz Flour (*Sorghum Oryzoidum*)

By Rodica Siminiuc & Dinu Țurcanu

Technical University of Moldova

Abstract- The assortment of gluten-free flours in the Republic of Moldova is very small, and the properties of these flours are not sufficiently studied. Sorghum (*Sorghum Oryzoidum*) is a relatively new cereal, the industrial production of which has recently begun, and the use of sorghum and derivatives, especially flour, are current. The purpose of this study is to determine the chemical composition and nutritional value of sorghum flour. This would have a direct impact on human well-being, contribute to the development of novel foods and reduce food insecurity in the Republic of Moldova, including people with gluten-related disorders. Physico-chemical methods were used to determine the chemical composition and nutritional aspects of the flour. The obtained results showed that the chemical composition of soriz flour is complex and similar to cereal flours, with a predominance of carbohydrates, followed by proteins, lipids etc.

Keywords: *chemical composition; nutritional value; sorghum flour (sorghum oryzoidum).*

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Physico-Chemical and Nutritional Characteristics of Soriz Flour (Sorghum Oryzoidum)

Rodica Siminiuc^α & Dinu Țurcanu^σ

Abstract- The assortment of gluten-free flours in the Republic of Moldova is very small, and the properties of these flours are not sufficiently studied. Sorghum (*Sorghum Oryzoidum*) is a relatively new cereal, the industrial production of which has recently begun, and the use of sorghum and derivatives, especially flour, are current. The purpose of this study is to determine the chemical composition and nutritional value of sorghum flour. This would have a direct impact on human well-being, contribute to the development of novel foods and reduce food insecurity in the Republic of Moldova, including people with gluten-related disorders. Physico-chemical methods were used to determine the chemical composition and nutritional aspects of the flour. The obtained results showed that the chemical composition of soriz flour is complex and similar to cereal flours, with a predominance of carbohydrates, followed by proteins, lipids etc. Protein fractions of flour are predominant of prolamins and glutenins, but are not generators of gluten. Soriz flour proteins are unbalanced in most essential amino acids relative to the reference protein, especially lysine. Therefore, it is justified to combine it with other foods such as eggs, meat, fish, milk, whose proteins are balanced in essential amino acids. Soriz flour is a good source of potassium and magnesium, but it is poor in such elements as phosphorus, calcium, iron and sodium. The content of tannins and phytates is close to the values mentioned in the literature for other categories of cereal flours. Soriz could be used in both common and gluten-free diets, helping to diversify the range of cereals, but also to increase food security.

Keywords: *chemical composition; nutritional value; sorghum flour (sorghum oryzoidum).*

I. INTRODUCTION

Cereals and cereal products are the basic element in ensuring the food security of the population, providing the major share of energy and nutrients in the daily diet (Kulamarva et al., 2009), (Sarwar, 2013). The importance of cereals and cereal derivatives is also supported by the fact that global food security depends to a large extent on cereal production, which amounts to approximately 2762 million tonnes per year (FAO, n.d.). Regarding the importance of cereals and the challenges

in food consumption patterns, it should be emphasized that the analysis of energy and nutrient sources is crucial to ensure their adequate nutritional quality (Laskowski et al., 2019). Diversified nutrition is one of the principles of rational nutrition, with direct benefits for human well-being and lifestyle.

Sorghum is one of the main basic food crops, traditional in many developing countries, being the fifth most important cereal crop in the world after rice, wheat, corn and barley. It is the main grain food for over 750 million people living in the semi-arid tropical regions of Africa, Asia and Latin America. Sorghum is also an interesting ingredient in gluten-free product formulations (Schober et al., 2005). Gluten-related disorders are on the rise, wreaking havoc on both children and adults. For people diagnosed with malabsorption, celiac disease, allergy or sensitivity to gluten, the consumption of products containing gluten, more precisely containing toxic prolamins, is strictly forbidden, because even in very small quantities, they can cause serious health disorders, and in extremely severe cases they can lead to cancer or even death (Renzetti et al., 2008), (Marengo et al., 2015).

Soriz is a hybrid of sorghum that is characterized by glassy endosperm, similar to rice. It was obtained at the Institute for Scientific Research for Maize and Sorghum in the Republic of Moldova, by crossing Sudan grass (*S. sudanense*) and bicolor sorghum (*S. bicolor*) (Galaiev et al., 2011). It is a relatively new cereal crop for the Republic of Moldova. The advantages of cultivating soriz are manifested in the production process, which does not require major investments: the plant is not demanding to soil conditions, fertilizers and has tolerance to diseases and pests (Rodica Siminiuc and Țurcanu, 2020). Previous research on the chemical composition of whole soriz grains shows a starch content - 74.12% ... 82.0% dm, protein - about 13.0% dm, sugars - 0.24% - 0.37% dm, lipids - 0.1% ... 0.5% dm, ash - 0.36% - 2.0% dm. In the whole soriz bean, the dominant protein fractions belong to prolamins (56.0% of the total protein), followed by glutelin (22.4%), globulins (7.3) and albumin (6.7) (Siminiuc Rodica et al., 2012).

The controversial information on the origin of sorghum in the category of gluten-generating cereals, as well as the provisions of European legislation

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regarding the control and proper management of raw materials used in the manufacture of gluten-free products were imperative factors for testing soriz in the presence of toxic prolamins. The results of laboratory tests by ELISA method (Enzyme-Linked Immunoassay R5 Mendez) confirmed the gluten-free character of soriz and, respectively, the admissibility of its inclusion in the diet of people with gluten-related disorders (Siminiuc, Rodica, 2012).

The assortment of gluten-free flours in the Republic of Moldova is very small, and the properties of these flours are not sufficiently studied. Soriz is a relatively new cereal, and the industrial production of soriz flour, due to its high glassiness, has recently begun. Attempts are made to use soriz flour in the elaboration of bakery, pastry, biotechnology products, but the need for research still remains current (R.

Siminiuc and Țurcanu, 2020), (Siminiuc, Rodica, 2020). Therefore, the purpose of this study is to identify the nutritional and technological and functional value / quality of sorghum flour.

This will help to capitalize on this cereal crop and, respectively, to diversify the diet. At the same time, it would have a direct impact on human well-being, contribute to the development of novel foods and reduce food insecurity in the Republic of Moldova, including people with gluten-related disorders.

II. MATERIALS AND METHODS

For the determinations, soriz flour was used, with the following organoleptic characteristics (Table 1) (Siminiuc, Rodica., 2014).

Table 1: Organoleptic characteristic of soriz flour

Indices	Eligibility conditions
Color	White color with yellowish tinge
Odor	Specific to sorghum flour, without foreign odor, rancid or moldy
Taste	Neutral taste, no foreign taste, sour or bitter.

The determinations for the identification of the physico-chemical and nutritional characteristics of sorghum flour are presented in Table 2.

Table 2: Methods used for determinations

Determined indices	Method / source
Moisture Determination	(Horwitz and AOAC International, 2006)
Protein Determination	Kjeldahl method (Association of Official Analytical Chemists and Helrich, 1990)
Protein fractions	The method is based on extracting protein fractions from cereals by solubilizing them in various media (Heldt and Heldt, 2011)
Amino acids	(Kosarenko, T., D. /КозаренкоТ.,Д., 1975)
Starch content	(ISO 10520:1997, 1997)□
Total Carbohydrate	(Association of Official Analytical Chemists and Horwitz, 2000)
Cellulose	(Association of Official Analytical Chemists and Horwitz, 2000)
Fat Content Determination	Soxhlet extraction method utilizing n-hexane (AOAC, Method 4.5.01) (St. Paul, MN.USA., 2000)
Ash Determination	(Association of Official Analytical Chemists and Helrich, 1990)
Mineral elements	(Association of Official Analytical Chemists and Helrich, 1990)□
Phytates	(Latta and Eskin, 1980)□
Tannin Content	(Burns, 1971)

III. RESULTS AND DISCUSSIONS

a) The chemical composition of soriz flour

As a rule, the chemical composition of cereal derivatives is close to that of the grains from which they come, depending on the processing processes to which they are subjected.

Soriz flour contains 86.03% / d.m. total carbohydrates, of which 83.5% belong to starch, 1.83% / d.m. mono and disaccharides and 0.7% / d.m. of

cellulose. The lipid content is 1.9% / d.m. (Figure 1). The respective values are lower than some varieties of sorghum flours, whose numerical values oscillate between 2.89 ... 3.17% / d.m. The humidity of soriz flour is $11.2 \pm 0.1\%$. Cereal proteins form the second main component after carbohydrates, the average content of which varies between 7% and 17%. The protein content in soriz flour is 11.2% / d.m. and is similar to the values of sorghum flours mentioned in the literature (10.26 ... and 12.14% / d.m.) (Verma, et al., 2018).

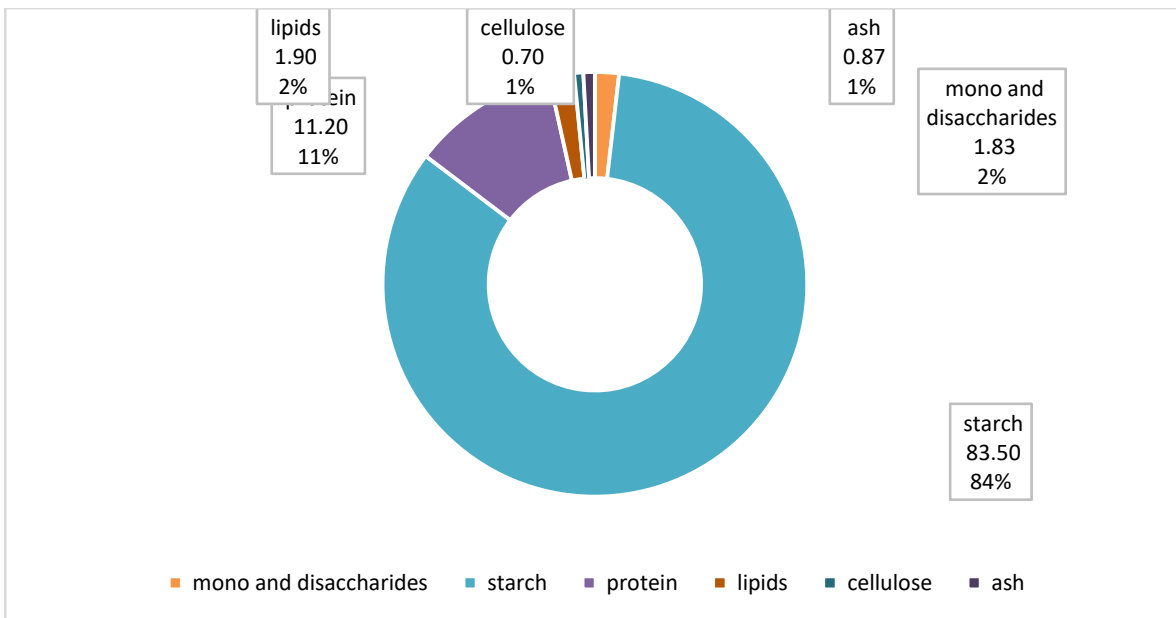


Figure 1: The chemical composition of soriz (Sorghum Oryzoidum) flour

Protein fractions in cereals directly influence their technological properties. Osborne classifies proteins according to solubility: gliadins are soluble in 70% ethanol, glutenins are soluble in dilute acid or alkaline solution, albumin is soluble in water, and globulins are soluble in dilute NaCl solutions. The focus of research on the qualitative aspects of proteins has been influenced by the technological importance of this category of nutrients. The share of albumin and globulins in the protein of sorghum flour is relatively small, constituting 12.9%. Gluten is the main protein fraction in wheat and other grains and is made up of glutenins and prolamins.

Prolamins (gliadins) and glutenins are recognized as major grain storage proteins, accounting for about 75-85% of all cereal proteins. The majority of protein fractions in soriz flour is represented by prolamine-about 58.4%, being close, by content, to sorghum (24.0... 55.0%) and followed by wheat (40.0... 42.0 %) and corn (22.6... 44.0%). The share of glutelin is about 22.1% of total protein (Figure 2). In bibliographic sources there are values of glutenin content between 18.3% and 40.0% (wheat), 39.0... 40.0% (sorghum), 26.6... 4.0 (corn) and 40, 0... 60.1% (rice).

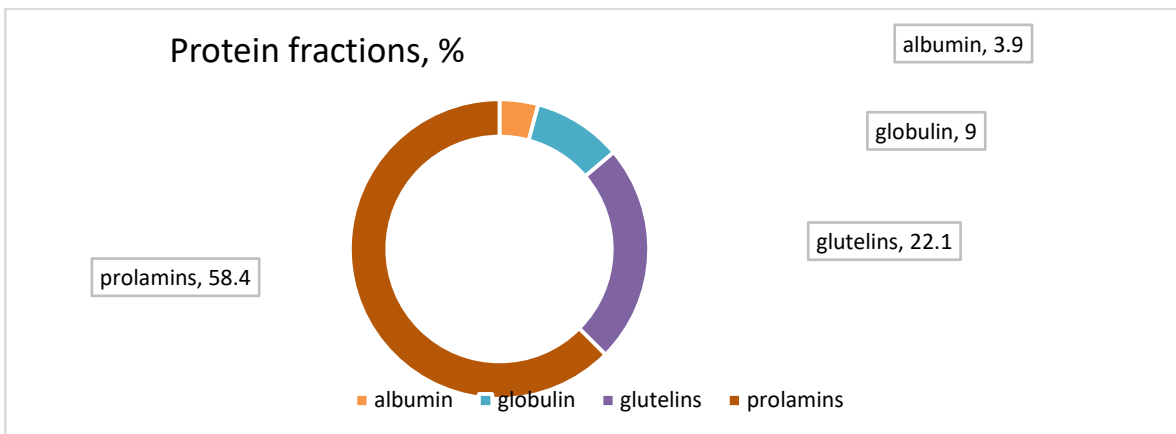


Figure 2: Protein fractions of sorghum flour

Both gliadin and glutenin comprise numerous protein components, characterized by minimal structural compositional differences (micro heterogeneity (Figoni, 2011).

These properties justify the primary role of gluten in the manufacture of bakery products. Gliadin controls the extensibility and volume of bread, and

glutenins are responsible for the elasticity of the dough and its kneading conditions (Barak et al., 2014).

Although soriz flour contains gluten-generating protein fractions, it should be noted that the properties of gluten are determined by the tertiary and quaternary structure of proteins, the primary and secondary structure having a smaller role. There is a correlation

between the rheological properties of the dough and the content of -SH and -SS- groups.

As the strength of the flour increases, the content of -SS- groups increases and that of -SH decreases. For a -SS - / - SH ratio of 15/19 a maximum volume of bread is obtained. The volume of bread increases with increasing protein content of flour, but depends on their quality. It is accepted that the elastic-viscous properties of the dough, which determine the quality of bakery products are the results of the interaction between the polymers of glutenins, but also between them and gliadin.

The glutenin / gliadin ratio was considered as a flour quality factor, and the optimum is assumed to be 43.5 / 46.5 or 1.0 / 1.06. The ratio of non-gluten and gluten fractions (glutenin / gliadin) in soriz flour is 1 / 2.6, which confirms the inability to form gluten in aqueous medium, and the use of flour in the manufacture of bakery products is a major challenge (Lásztity, 1996).

b) *Nutritional value*

i. *Amino acid content*

Cereal proteins are second - and third - class proteins, with an average biological value, compared to standard proteins, due to the presence of lysine (in some cereals threonine) in proportions lower than human needs. Knowing the amino acid content of proteins, especially the essential ones, are important indicators in assessing the nutritional quality of traditional cereal products as well as those obtained from new sources of raw materials.

Soriz flour proteins are poor in such amino acids as lysine, methionine, tryptophan, which is directly correlated with the low content of protein fractions: albumin and globulin. These nutritional fractions are usually well balanced in amino acids. The quantitative content of amino acids is found in Figure 3(Laze et al., 2019).

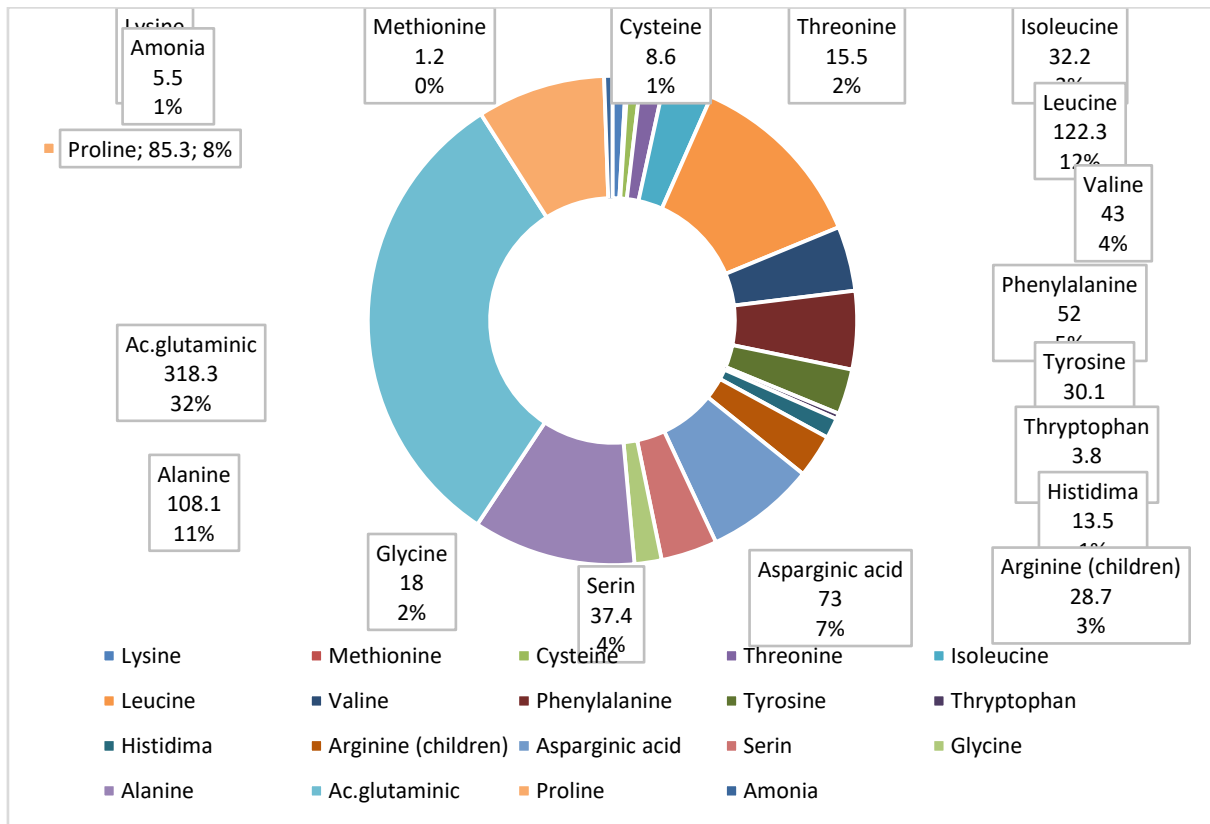


Figure 3: The amino acid content of sorghum flour

The sum of non-essential amino acids is about 68% of their total in protein (Table 3). The high content of alanine (96.0%), proline (90.01%) and glutamic acid (302.0%) is explained by the percentage distribution of protein fractions, the majority of which, in soriz flour, belongs to prolamins and which is characterized by a high content of glutamic acid (13.7 - 43.3%) and proline (6.3-19-3%) (Laze et al., 2019). The content of aromatic amino acids is 82.1 mg / g protein and, although not

part of the essential amino acids, is considered to directly amplify the mental energy level.

Table 3: The amino acid content of sorghum flour Totalisation

Amino Acids	mg / g protein
∑ the total amount of AA	1000
Nitrogen metabolism index	1005,5
∑ non-essential AA	682,3
∑ essential AA	317,7
∑ glyco-genic AA	295
∑ keto-genic AA	249,0
∑ proteinogenic AA	1000
∑ sulfur AA	9,8
∑ aromatic amino acids AA	82,1

Essential amino acids make up 32% of the total number of amino acids. According to the results obtained, the flour flour proteins are unbalanced in most of the essential amino acids in relation to the reference protein, namely: sulfur amino acids (methionine and cysteine) (IC = 28), threonine (IC = 38.5), isoleucine (IC

= 80.5), valine (IC = 86), tryptophan (IC = 38) (Figure 4).

However, the limiting amino acid remains lysine (IC = 16), which is characteristic of most cereals except corn, in which the limiting amino acid is tryptophan (Zaparrart and Salgado, 1994).

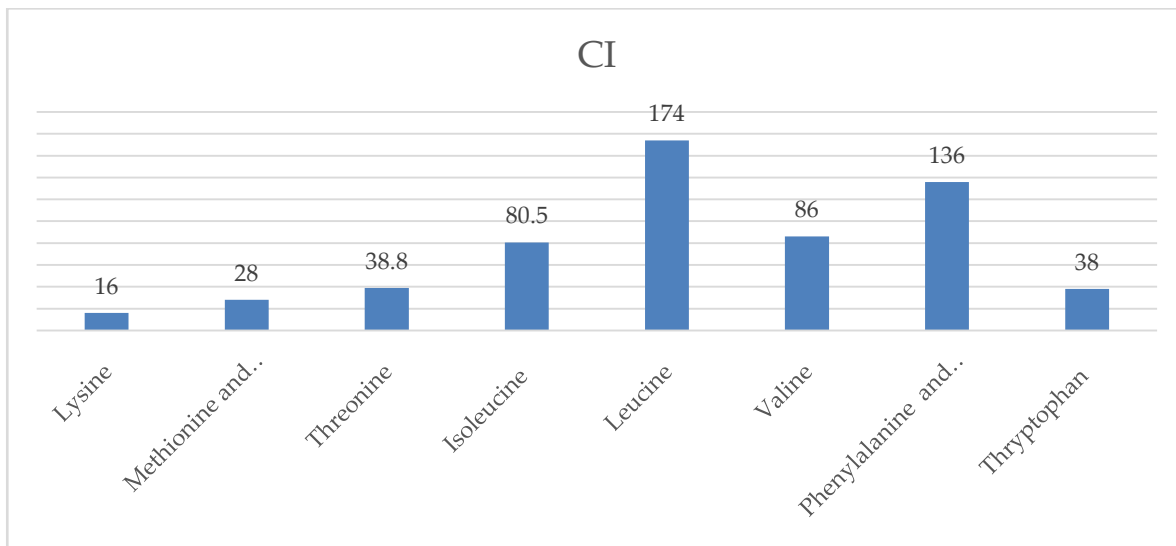


Figure 4: Chemical Index (CI) of sorghum flour

ii. Mineral content

The concentration of mineral elements in cereals and cereal derivatives varies depending on genotypic and environmental influences, as well as the degree of technological processing. Table 4 presents the experimental data on the content of mineral elements in soriz flour. Although the content of mineral elements in soriz flour respects almost entirely the consistency specified in the literature, namely: K > P > Mg > Ca > Na > Fe (120,1 > 89,04 > 33,16 > 4,5 > 1,19 > 1.07) (Paola Pontieri* and Jacopo Troisi, 2014), with the exception of Ca and Na, however, it is necessary to mention that the values obtained are lower than the

values indicated in specialized references for sorghum and their derivatives (Tasie and Gebreyes, 2020). Soriz flour is a good source of potassium and magnesium, but is poor in calcium, iron and sodium phosphorus.

Table 4: Conținutul unor elemente minerale în făina de soriz

Mineral elements	Soriz flour, mg/%.d.m.	Husked sorghum mg/g ¹ (FAO.Codex Alimentarius Commission, 1995)	Sorghum Bicolor (L) mg kg ⁻¹ (Gerrano et al., 2016)
Na	1,19 ± 0,03	-	30,83
Ca	4,5 ± 0,2	21	277,5
Fe	1,07 ± 0,05	2,8	55,13
K	120,1 ± 0,3	1,8	1262,5
P	89,04 ± 0,06	1,15	2944,5
Mg	33,16 ± 0,02	0,3	1237,5

iii. *Content of antinutritional substances*

In addition to the nutrients so necessary for the development of vital processes, cereals also contain a number of factors (tannins, phytates), which reduce or block the assimilation of nutrients. Subsequently, it has been shown that tanning substances have the ability to precipitate saliva proteins, combine non-specifically with food proteins, forming complexes resistant to gastrointestinal enzymes, inhibit the absorption of Fe, Zn and some vitamins. Enzymes inhibited by tanning substances include proteases, lipases and amylases, which are indispensable for the subsequent degradation of proteins, lipids and polysaccharides in food into simpler and easily assimilable substances (Wu et al., 2012).

Phytic acid is found in virtually all cereal seeds, especially on the outside (coating), but also on the

inside, constituting up to 80% of the plant's reserve phosphorus. The content of phytic acid in cereals varies from 0.5 to 2.0%. Due to its chemical structure, phytic acid chelates multivalent metal ions: Ca, Mg, Fe, Zn and Cu, but also forms complexes with proteins (Coulibaly et al., 2010). The bonds formed are so strong that to be cleaved requires the action of phytase, an acid phosphatase found in seeds and activated in the germination process (presence of water and acidic environment), releasing minerals for plant growth (He et al., 2007). This process is welcome for the plant, but the human body does not synthesize phytase, so it is important to know the possibilities of reducing phytates in the human diet.

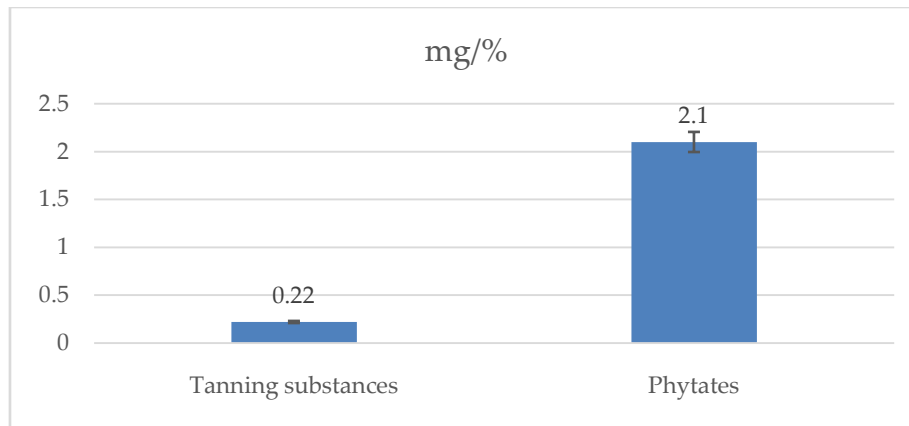


Figure 5: The content of tannins and phytates in sorghum flour

The average content of tannins and phytates is shown in Figure 5. The results obtained are comparable to the content of tannins in other cereals such as sorghum (0.23 ... 0.51 mg /%), white Indian millet (0.06%) , brown Indian millet (3.74 mg /%). In the human diet the daily consumption of tanning substances in a varied diet can be estimated at 1.0 - 2.5 grams E to mention that the action of anti-nutrients on the body, in general, is weaker than natural toxins and is manifested only in

following an unbalanced diet. Quantitative knowledge of the content of anti-nutritive substances allows the selection of appropriate technological / biotechnological processes for processing cereals, in order to reduce, to the admissible limit, the amount of nutrients.

IV. CONCLUSIONS

The chemical composition of soriz flour is complex and similar to cereal flours, with a

predominance of carbohydrates, followed by proteins, lipids, etc. Protein fractions of flour are predominant of prolamins and glutenins, but are not gluten-generating. The proteins of soriz flour are unbalanced in most essential amino acids in relation to the reference protein, namely: sulfur amino acids, threonine, isoleucine, valine, tryptophan. The obtained results confirm that the nutritional quality of sorghum flour proteins, evaluated according to the chemical index, is low. Therefore, their association with other foods such as eggs, meat, fish, milk, whose proteins are balanced in essential amino acids, is justified. Soriz flour is a good source of potassium and magnesium, but is poor in minerals (phosphorus, calcium, iron and sodium). The content of tannins and phytates is close to the values mentioned in the literature for other categories of cereal flours. Soriz can be used in both common and gluten-free diets, helping to diversify the range of cereals and increase food security.

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CHIARA: Cost of Holding Interruptions of Availability via Reliability Analysis

By F. Galetto

Abstract- Attending seminars, Conferences, looking at "television lessons" the author saw many times many people (often Professors) that did not know the matter they were talking about [as Deming wrote "the 1st requisite for a good teacher is that he have something to teach... must possess knowledge of the subject"]; nevertheless many of them still write papers, suggest "wrong" books to students, provide "wrong" lessons, make consultancy. Visiting Companies the author saw many times many Companies lacking Quality of Management, a big problem against Quality achievement.

Many lecturers on "quality matters" and on "reliability matters" do not know, in a scientific way, reliability theory; therefore, they propose wrong methods to students. The basic reliability ideas are easily understandable, but when you need more sophisticated methods many people do more harm than good. In the paper we present a case related to contractual clauses on failures and related costs; we show that even in this simple case, the Reliability Integral Theory (devised by F. Galetto to overcome limitations on the usual methods in reliability) is needed.

Companies' solutions and real applications are an important problem: wrong solutions depend on the lack of scientific knowledge.

Keywords: quality education, quality methods, quality tetralogy, intellectual honesty, scientificity, SPQR, reliability.

GJRE-J Classification: FOR Code: 091599



CHIARA COST OF HOLDING INTERRUPTIONS OF AVAILABILITY VIA RELIABILITY ANALYSIS

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I. INTRODUCTION

As said by the author [2], "Higher Education is seen many times as a Production System, and students are considered as its "Customers". Books and magazines are suggested to students attending "Quality Courses" at Universities. Some of

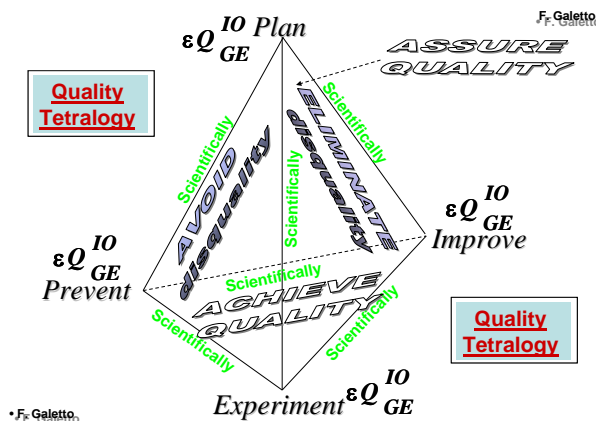
them are good, some are not so good. Students use papers from magazines for their teaching; some have good Quality; some are not very good. Therefore it seems important to stand-back a bit and meditate, starting from a managerial point of view."

In order not to be cheated, any person should use the SPQR («Semper Paratus ad Qualitatem et Rationem») Principle [1]: anybody must be attentive to use his Rationality to find if the quality is present or absent in any activity.

Generally, engineers do not learn Quality matters and specially they know very little about Reliability: System Reliability, Reliability Theory, Reliability Tests, Availability Theory, Cost related to Un-Reliability and UN-Availability, even though the lessons are provided by professors members of the "Politecnico Quality Engineering Group (QEG)" (all graduated CUM LAUDE) [Fausto Galetto, who always was striving for Quality scientific applications, is not a member of QEG!].

Many professors teaching "quality" do not have enough knowledge: to deal properly with those matters, Probability Theory and Statistics are essential [as stated by W.E. Deming].

"To "measure" Quality (?), various bibliometric indices (e.g., h-index, s-index, ...) have been devised, based on informetric models. Quality (?) of Research, in many universities, is based on these indexes: if you are cited many times, you are a better professor than if you are not!" [2].



Deming The result is that hundreds of people are learning what is wrong. I make this statement on the basis of experience seeing every day the devastating effects of incompetent teaching and faulty applications. Deming

Figure 1: Deming's and Galetto's ideas about Quality and Teaching

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Galileo Galilei, Einstein, Jay, Deming, Berne, Feynman (to mention only very few) were champions before F. Galetto, in the SPQR Principle, without naming it.

“To grasp the importance of these ideas, let’s imagine that in one university there is a Quality Engineering Group (QEG, comprising four lecturers, *all graduated CUM LAUDE*, and teaching “Quality matters”; they are also in the Research Gate *with high Impact Points!*). Any rational person shall expect that those people teach good ideas and will write “Quality papers on Quality matters”. QEG experts do think firmly that only “Peer Reviewed papers” and “Citations” are important for Quality... Do they act correctly or wrongly?” [2] Consider the following case: Minitab software computes the T Charts Control Limits for exponential and Weibull distributed data for the so-called “rare events”; it happens that, using the SPQR Principle and Statistics good Theory, those Control Limits are wrong. The same happens for other software. If professors use that software for teaching either Quality or Statistics do they act correctly or wrongly?

“Is there any Quality in wrong teaching? Teaching must be scientific for future managers, as Deming and Galetto say (fig. 1).”[2] If the reader want he can find some cases in the references [from 10 to 21].

In the appendix, we provide some ideas about scientificity; we suggest reading it, before going on: it is useful but not compulsory.

“To show how teaching fails to attain his goal (i.e. to prepare students for the future), the paper will use a simple case:”[2] the analysis of a 2-state system, where requirements on the number of failures(N_i), on the length of downtime (x) and on the maximum number of Long Downtimes (N_{LD}) are fixed in a supply contract of the system; if the supplier does not meet the stipulated goals he must pay the penalty. We use the SPQR approach [1].

In this introduction, we provide here some basic ideas of Reliability Theory [from 22 to 31], useful for Reliability Analysis and other methods (e.g., inventory, the Bass model analysis, ...). The following concepts are taken from [2].

Let T be the random variable “Time to failure” of an item, and $0 \leq t$ the mission interval, whose duration is t . The reliability $R(t)$ is the probability that no failure happens during the mission, with $f(t)$ being the pdf,

$$R(t) = P[T > t] = 1 - F(t) = \int_t^\infty f(x)dx \quad (1)$$

The mean of the r.v. T is the Mean Time To Failure

$$MTTF = E[T] = \int_0^\infty xf(x)dx = \int_0^\infty R(t)dt \quad (2)$$

The failure rate $h(t)$, as any good student knows, is neither a (conditional) probability density nor a (conditional) probability; it is the ratio

$$h(t) = f(t) / R(t) \quad (3)$$

Hence it is easily derived that

$$R(t) = \exp\left[-\int_0^t h(x)dx\right] \quad (4)$$

When the failure rate is constant, the failures are distributed “in the most random manner”: the conditional reliability does not depend on the item past life.

It is easily seen that the knowledge of the failure rate $h(t)$ is enough to obtain any reliability characteristic [$R(t)$, $MTTF$, $MTTF(t)$, $F(t)$, $f(t)$].

The Mean Time to Failure, related to the interval $0 \leq t$, is

$$MTTF(t) = \int_0^t R(x)dx \quad (5)$$

The same ideas are also valid for maintenance. Let T_r be the random variable “Time to repair” of an item, and $0 \leq t$ the interval considered for repair, whose duration is t . The reparability $G(t)$ is the probability that a repair happens in the mission, $g(t)$ being the pdf (the time 0 is the instant at which the item fails)

$$G(t) = P[T < t] = \int_0^t g(x)dx \quad (6)$$

The mean of the r.v. is the Mean Time To Repair

$$MTTR = E[T_r] = \int_0^\infty xg(x)dx = \int_0^\infty [1 - G(t)]dt \quad (7)$$

The repair rate, as any good student knows, is neither a (conditional) probability density nor a (conditional) probability; it is the ratio

$$r(t) = g(t) / [1 - G(t)] \quad (8)$$

Hence it is easily derived that

$$\bar{G}(t) = 1 - G(t) = \exp\left[-\int_0^t r(x)dx\right] \quad (9)$$

When the repair rate is constant, the repairs are distributed “in the most random manner”: the conditional reparability does not depend on the past repairs.

The Mean Time To Repair, related to the interval $0 \leq t$, is

$$MTTR(t) = \int_0^t \bar{G}(x)dx \quad (10)$$

Let’s now see the concept of Availability.

Let’s assume that we have a system that is repaired after any failure; let U_i the time of survival to the i -th failure, measured from the previous repair [Up time]; let D_i the time from the i -th failure to the next repair

[Down time]; both are random variable: their means are the Mean Up Time MUT_i and the Mean Down Time MDT_i ; the sum $D_{i-1}+U_i$ is the Time Between Failures, from the (i-1)-th failure to the i-th failure [it is a random variable]: the mean of it is the $MTBF_{i-1, i}$ Mean Time Between Failures, from the (i-1)-th failure to the i-th failure.

If $f_i(t)$ is the density of the Up time U_i , we have

$$MUT_i = E[U_i] = \int_0^\infty x f_i(x) dx \quad (11)$$

while if $g_i(t)$ is the density of the Down time D_i , we have

$$MDT_i = E[D_i] = \int_0^\infty x g_i(x) dx \quad (12)$$

By defining $z_i(t)$ is the density of the "Cycle time", from an up-state of the system (when it works well) to the next up-state of the system (when it works well, again), we have that $z_i(t)$ is the convolution $f_i(t)*g_i(t)$ of the two densities $f_i(t)$ and $g_i(t)$; then the Mean Cycle Time MDT_i is

$$MCT_i = \int_0^\infty x z_i(x) dx = E[U_i + D_i] \quad (13)$$

When all the r.v. U_i are identically distributed, we indicate with $f(t)$ the probability density of the r.v. U ; when all the r.v. D_i are identically distributed, we indicate with $g(t)$ the probability density of the r.v. D ; when the r.v. U and D are identically distributed, we indicate with $z(t)$ the probability density of the r.v. $U+D$.

In that case, we have the means MUT , MDT , $MCT=MTBF$ (Mean Time between Failures).

In the next sections, we shall start to deal with our the analysis of a 2-state system, where requirements on the number of failures and the length of downtime are stated goals in a supply contract of the system (if the supplier does not meet the stipulated goals he must pay the penalty), by working, step by step, from a simple model to amore complete model.

We will use the Reliability Integral Theory devised by Fausto Galetto to overcome the Markov process theory used for reliability calculations. [22-31]

In the next section, we provide some concepts on reliability and availability.

II. RELIABILITY AND AVAILABILITY

Let's consider now our system, as depicted in the following flow graph.

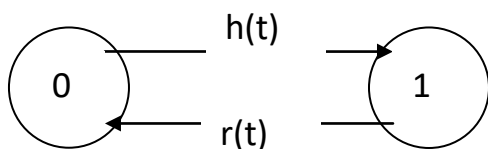


Figure 2: A 2-state system, with failure rate $h(t)$ and repair rate $r(t)$

We consider only a very simple system to provide fundamental concepts.

State 0 of the system is the state where it works well and can fail with failure rate $h(t)$, while state 1 is the state where the system is failed and under repair with repair rate $r(t)$: in 0 the system is up, in 1 the system is down.

We assume that the process failure-repair is regenerative: any time the system enters a state, the process starts from scratch: the system is GAN, as Good As New. The failure-repair process is a Semi-Markov process. [22-24, 28-31]

Let $A_0(t)$ be the Availability of the system, i.e., the probability that the system is working well at time t , when it entered the state 0 at time $t=0$; let $A_1(t)$ be the Availability of the system, i.e., the probability that the system is working well at time t , when it entered the state 1 at time $t=0$.

Using the Availability Integral Theory [F. Galetto, 22-24, 28-31] we write the following system of "INTEGRAL" equations

$$A_0(t) = R(t) + \int_0^t f(s) A_1(t-s) ds \quad (14)$$

$$A_1(t) = \int_0^t g(s) A_0(t-s) ds$$

We can reduce it to a single "INTEGRAL" equation [using the cycle density $z(r)$]

$$A_0(t) = R(t) + \int_0^t z(r) A_0(t-r) dr \quad (15)$$

Using the method of Peano-Picard, we can derive the solution in the form

$$A_0(t) = R(t) + \int_0^t m(r) R(t-r) dr \quad (16)$$

where the "intensity" $m(t)$ is given by

$$m(t) = z(t) + \int_0^t m(r) z(t-r) dr \quad (17)$$

Notice that the product $m(t)dt$ is probability that a cycle is completed in the interval $t \rightarrow t+dt$.

The integral

$$M(t) = \int_0^t m(r) dr = 1 - R(t) + \int_0^t z(r) M(t-r) dr \quad (18)$$

is the Mean Number of Cycles in the interval $0 \rightarrow t$.

Letting $t \rightarrow \infty$ one gets [22-24, 28-31] the Steady State Availability

$$A_0(\infty) = A_{SS} = \frac{MUT}{MUT + MDT} = \frac{MUT}{MTBF} \quad (19)$$

and asymptotic rate

$$m(\infty) = \frac{1}{MUT + MDT} = \frac{1}{MTBF} \quad (20)$$

IF the failure and repair rate are both constant, $h(t)=\lambda$ and $r(t)=\mu$, it is easily found [where $A(t)=A_0(t)$]

$$A(t) = \frac{\mu}{\mu + \lambda} + \frac{\lambda}{\mu + \lambda} \exp[-(\mu + \lambda)t] \quad (21)$$

It is easily seen that $A_{ss} = MTF/(MTF + MTTR) = MTF/MTBF$, as it must be.

IF the failure and repair rate are both constant, $h(t)=\lambda$ and $r(t)=\mu$, it is easily found, where $A(t)=A_0(t)$

$$m(t) = \frac{\lambda\mu}{\lambda + \mu} + \frac{\lambda^2}{\lambda + \mu} \exp[-(\lambda + \mu)t] = \lambda A(t) \quad (22)$$

It is easily seen that $m(\infty) = 1/(MTF + MTTR) = 1/MTBF$, as it must be.

NOTICE: the relationship $m(t)=\lambda A(t)$ is valid only when the failure and repair rate are both constant, $h(t)=\lambda$ and, $r(t)=\mu$. There are incompetent professors who teach the formula $m(t)=\lambda A(t)$ for variable failure and repair rates. [30, 31]

Before leaving this section, let's see what five "reliability experts" (are they experts?) of four different universities wrote in a booklet! Use the SPQR Principle.

The author gave it as Esercizio n. 5 (Exercise 5) to his students at the Quality Exam.

"A system is made by three units named GPS, TV e SC; the system performs properly when the items GPS and TV work well; if SC fails it is repaired; the items failures are considered independent; the professors draw the diagram on the left ("riparazione" = repair) and compute the system reliability. Then they (BMWists) have the "GREAT IDEA" that some failure could be dependent and draw the diagram on the right.

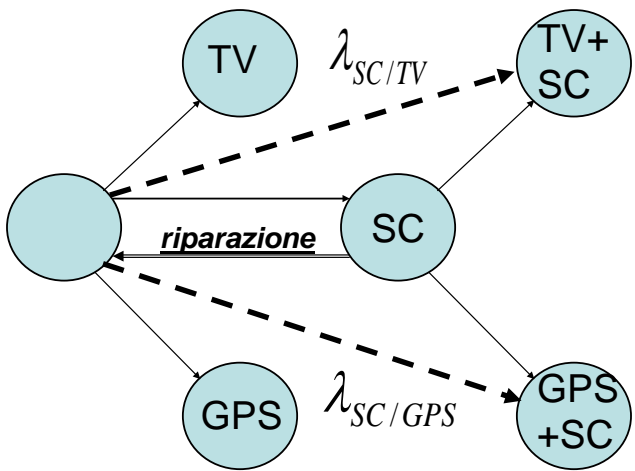
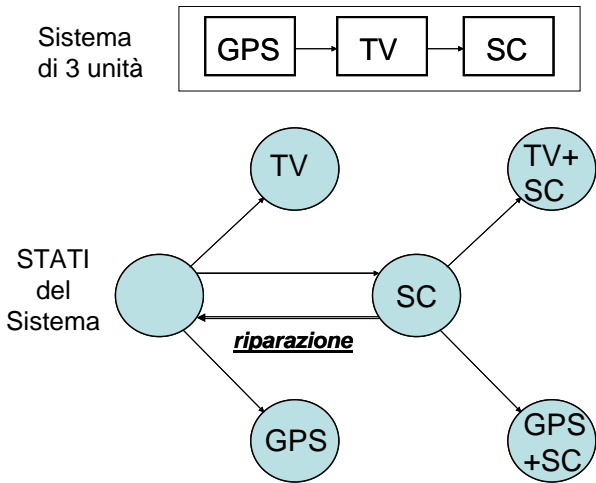


Figure 3: A 6-state system (3 units, "riparazione"=repair), in booklet written by 5 "reliability experts" of 4 different universities"

Notice the failure rates $\lambda_{SC/TV}$ and $\lambda_{SC/GPS}$ (dotted arrows), by the 4 professors were written to be

$$\lambda_{SC/TV} = \frac{\lambda_{SC}^2 \lambda_{TV} + \lambda_{SC} \lambda_{TV}^2}{\lambda_{SC}^2 + \lambda_{TV}^2 + \lambda_{TV} \lambda_{SC}} \quad \lambda_{SC/GPS} = \frac{\lambda_{SC}^2 \lambda_{GPS} + \lambda_{SC} \lambda_{GPS}^2}{\lambda_{SC}^2 + \lambda_{GPS}^2 + \lambda_{GPS} \lambda_{SC}}$$

The students had to be better than those professors, and FIND that the failure rates $\lambda_{SC/TV}$ and $\lambda_{SC/GPS}$ (dotted arrows) are ACTUALLY the formulae $1/MTF$ of the PARALLEL of the units SC/TV and SC/GPS!WRONG!

Can anyone believe to such professors? Use the SPQR Principle [1].

III. THE 1ST STEP: A POISSON PROCESS

Let's consider now our system, as depicted in the following flow graph.

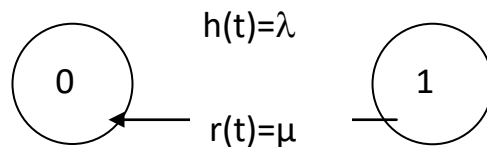


Figure 4: A 2-state system, with constant failure rate λ and repair rate μ

We will consider that the failure and repair rate are both constant, $h(t)=\lambda$ and $r(t)=\mu$.

We assume that the reliability goals are as follows:

1. During the mission time $0 \leq t \leq T$, a maximum number N_f of failures is accepted; if the number of failures n is $> N_f$, the supplier will pay a penalty P_f ;
2. During the mission time $0 \leq t \leq T$, at any failure, a maximum length of the downtime $< x$ is accepted; if the downtime is $> x$ (a stated value, named "Long Downtime"), the supplier will pay a penalty P_D ;
3. During the mission time $0 \leq t \leq T$, a maximum number N_{LD} of Long Downtimes is accepted; if the number of downtimes m is $> N_{LD}$, the supplier will pay a penalty $P_{NLD} > P_D N_{LD}$.

The 1st step for building our model is to consider only the number of failures; so doing we assume that the downtimes are very short (we assume them as not important; the repair rate $\mu \gg \lambda$ is a *strong assumption!*): in this case t , the duration of the mission, is "almost" the total up time.

The probability of the random variable N "number of failures", in the mission time $0 \leq t \leq T$, is

$$P[N = n] = \frac{(\lambda t)^n}{n!} \exp(-\lambda t) \quad (23)$$

Therefore the probability that the "number of failures" N , in the mission time $0 \leq t \leq T$, is $> N_f$ is

$$P[N \geq N_f] = 1 - \sum_{n=0}^{N_f} \frac{(\lambda t)^n}{n!} \exp(-\lambda t) \quad (24)$$

In this case, the supplier will pay a penalty P_f .

It is easily seen that in the chosen hypothesis we have a *Homogenous Poisson Process*. The probability of a "Long Downtime" x is

$$p = \exp(-\mu x) \quad (25)$$

Formula (25) is found by the following argument: let our system be in state 1 and let $\xi(t) = T_0 - t$ the duration from the present time t , when the system enters state 1, to the time that the repair is completed and the system enters state 0; we want to compute the probability $p(t+x|t) = P[\xi(t) > x]$ that the "time to repair" is longer than the stated "Long Downtime" x . From pages 169-173 of the book [24] one can write an integral equation whose solution is $p(t+x|t)$; from there it is found that $p(t+x|t) = p = \exp(-\mu x)$ when the repair rate is constant. The same result can be found in [23].

IF the repair rate $\mu \gg \lambda$ then the Homogenous Poisson Process of intensity λ , where we pick its points $[\xi(t) > x]$ with probability p , given by (25), becomes the Homogenous Poisson Process of intensity $p\lambda$; therefore (26)

$$P[M \geq N_{LD}] = 1 - \sum_{n=0}^{N_{LD}} \frac{(p\lambda t)^n}{n!} \exp(-p\lambda t) \quad (26)$$

Is the probability that the "number of Long Downtimes" M , in the mission time $0 \leq t \leq T$, is $> N_{LD}$; the supplier will pay a penalty P_{NLD} .

The formula (26) derives from the theory of Poisson Processes. We can get it using the Reliability theory, with the following arguments. Consider a process, named "auxiliary system", as in the following figure 5:

The "auxiliary system" works as follows:

1. It starts in state 1 (Up-state)
2. It re-enters state 1 with probability p
3. It goes to state 2 (Down-state) with probability $1-p$
4. The time to re-enter or to go out is provided by the exponential probability density with rate λ

Let $\Phi_{11}(n, t)$ be the probability of the joint event that the system will have made n transitions (re-entering) and will be in state 1, given that it started in state 1 at time $t=0$, and that time t has elapsed. We have

$$\Phi_{11}(n, t) = p^n \frac{(\lambda t)^n}{n!} \exp(-\lambda t) \quad (27)$$

Let $\Phi_{11}(t)$ be the probability of the system being in state 1 at time t , given that it started in state 1 at time $t=0$. By summing $\Phi_{11}(n, t)$ for all the values of n (from 1 to ∞), we have

$$\Phi_{11}(t) = \exp[-(1-p)\lambda t] \quad (28)$$

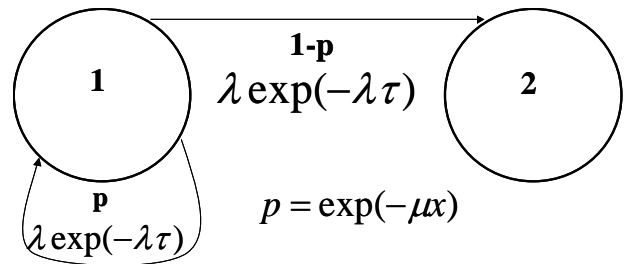


Figure 5: A 2-state, "auxiliary system", with constant failure rate λ and repair rate $\mu \gg \lambda$

The probability that the system experience n "long downtimes", given that time t has elapsed, and it occupies state 1

$$\frac{\Phi_{11}(n, t)}{\Phi_{11}(t)} = \frac{(p\lambda t)^n}{n!} \exp[-(1-p)\lambda t] \quad (29)$$

by doing the necessary operations, provides the formula (26).

We see then that, with the *strong assumption* $\mu \gg \lambda$ (the downtimes are very short and t is the total up time), it is very easy to compute the costs involved.

The probability that the "number of failures" $N(t)$, in the mission time $0 \leq t \leq T$, is $> N_f$ (and the supplier will pay a penalty P_f) is

$$P[N(t) \geq N_f] = F_{N_f}(t) \tag{30}$$

where $F_n(t)$ is the convolution $F(t) * F_{n-1}(t)$ with $F_1(t) = F(t)$.

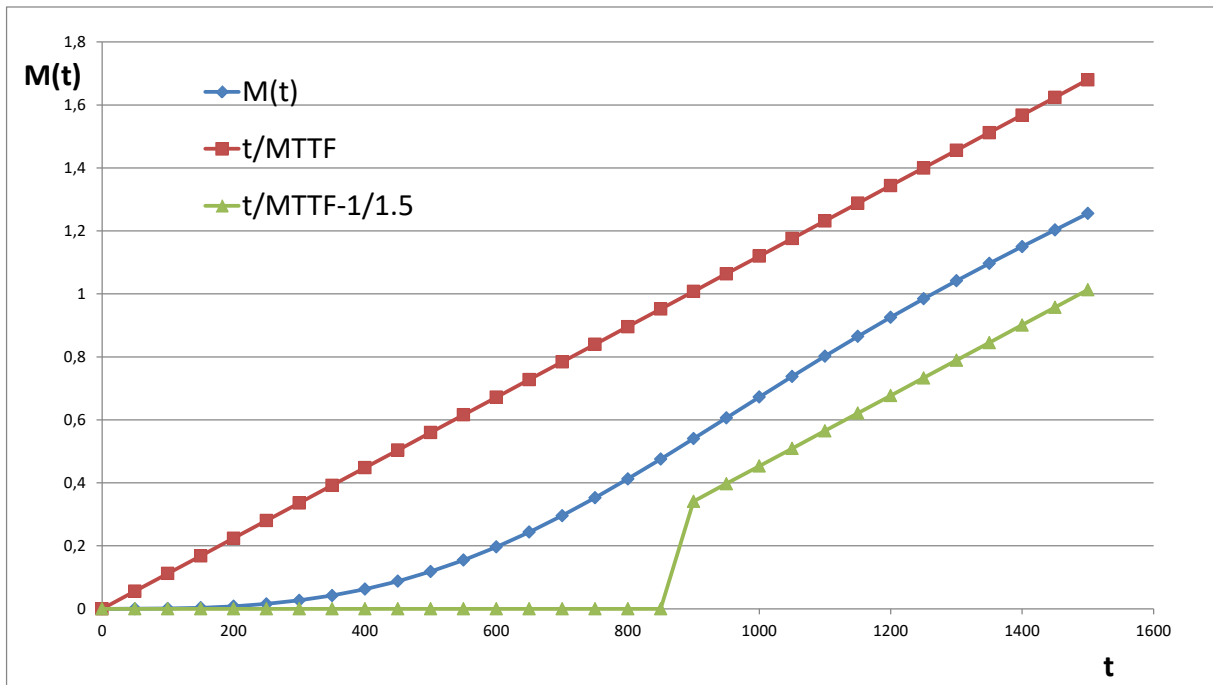


Figure 6: $M(t)$, $t/MTTF$, $t/MTTF-1/1.5$

From (30), one can derive the Mean Number of Failures in the interval $0 \dots t$

$$M(t) = F(t) + \int_0^t f(r)M(t-r)dr \tag{18b}$$

In the case that $h(t) = \lambda$, we have $M(t) = \lambda t$.

In all the sections, we consider a system with $MTTF=1000$ (units of time) and $MTTR=100$. These values do not conform “completely” with our *strong assumption* $\mu \gg \lambda$; despite that, they are chosen so that the graphs can show the different curves for the different cases. We state, $N_{LD}=4$ and $x=100$. When the reliability is Weibull with $MTTF=1000$, the $M(t)$ depends on the shape parameter β . For our case, we chose $\beta=3$. See figure 6.

IV. THE 2ND STEP: A “MODIFIED” POISSON PROCESS

Let's consider our system again, as depicted in the following flow graph.

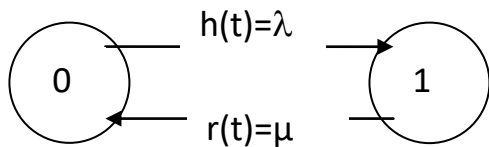


Figure 7: A 2-state system, with constant failure rate λ and repair rate μ

Again we consider that the failure and the repair rates are both constant, $h(t) = \lambda$ and $r(t) = \mu$.

We assume that the reliability goals are the same as in section 3.

As in the 1st step, we consider the number of failures, but now we do not assume that the downtimes are very short; they depend on the repair rate μ .

The probability of the random variable $N(t)$ “number of failures”, in the mission time $0 \dots t$, is no longer as the probability of the the number of points of a Homogenous Poisson Process.

We have a process with intensity $m(t)$ given by the formula (22), here repeated,

$$m(t) = \frac{\lambda\mu}{\lambda + \mu} + \frac{\lambda^2}{\lambda + \mu} \exp[-(\lambda + \mu)t] = \lambda A(t) \tag{22}$$

It is easily seen that after two cycles, the Availability and the cycling intensity are almost constant; therefore, after few cycles, the stochastic process becomes a Homogenous Poisson Process, with intensity $m(\infty) = 1/(MTTF + MTTR) = 1/MTBF = \lambda A_{SS}$.

The same happens when the failure and repair rates are variable [provided the system is renewable].: $m(\infty) = 1/(MTTF + MTTR) = 1/MTBF$. See figure 7-

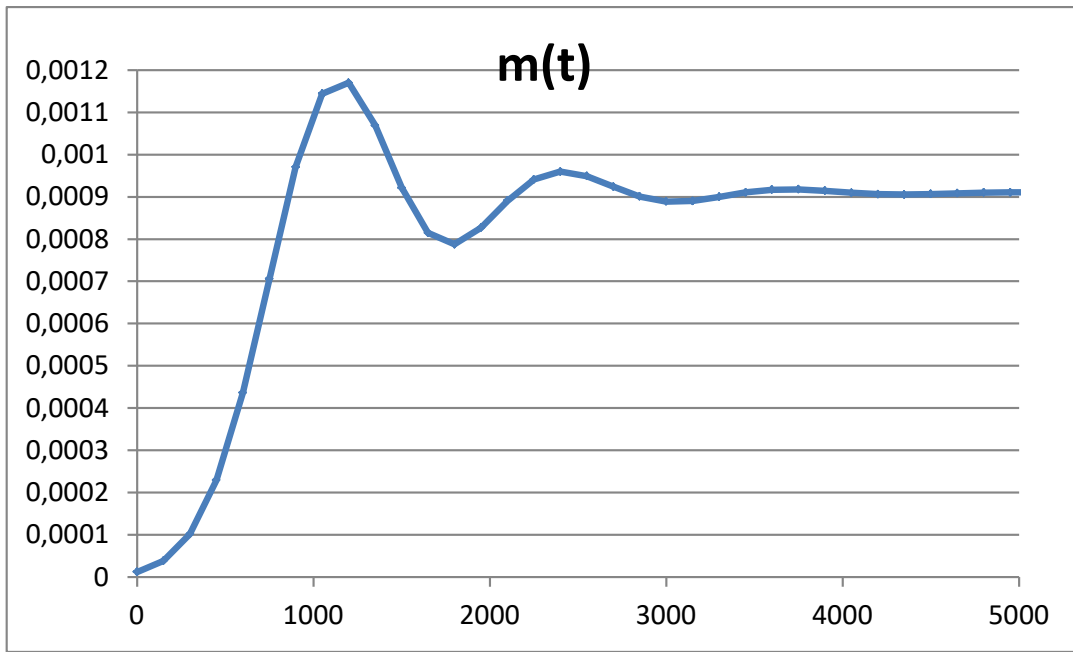


Figure 8: Example of the intensity $m(t)$ when the failure rate and the repair rate are variable (e.g., Weibull)

Therefore, when the failure and repair rate are both constant, $h(t)=\lambda$ and $r(t)=\mu$, the probability that the “number of failures” N , in the mission time $0 \dots t$, is $> N_f$ is

$$P[N \geq N_f] = 1 - \sum_{n=0}^{N_f} \frac{(\lambda A_{SS} t)^n}{n!} \exp(-\lambda A_{SS} t) \quad (31)$$

The supplier will pay a penalty P_f .

The probability of a “Long Downtime” x is, as in section 3, $p = \exp(-\mu x)$ and we pick the points (of the process) with probability p , given by (25); therefore (32)

$$P[M \geq N_{LD}] = 1 - \sum_{n=0}^{N_{LD}} \frac{(p \lambda A_{SS} t)^n}{n!} \exp(-p \lambda A_{SS} t) \quad (32)$$

is the probability that the “number of Long Downtimes” M , in the mission time $0 \dots t$, is $> N_{LD}$; the supplier will pay a penalty P_{NLD} .

We see again that it is very easy to compute the costs involved. See the related probabilities for C1 and C2.

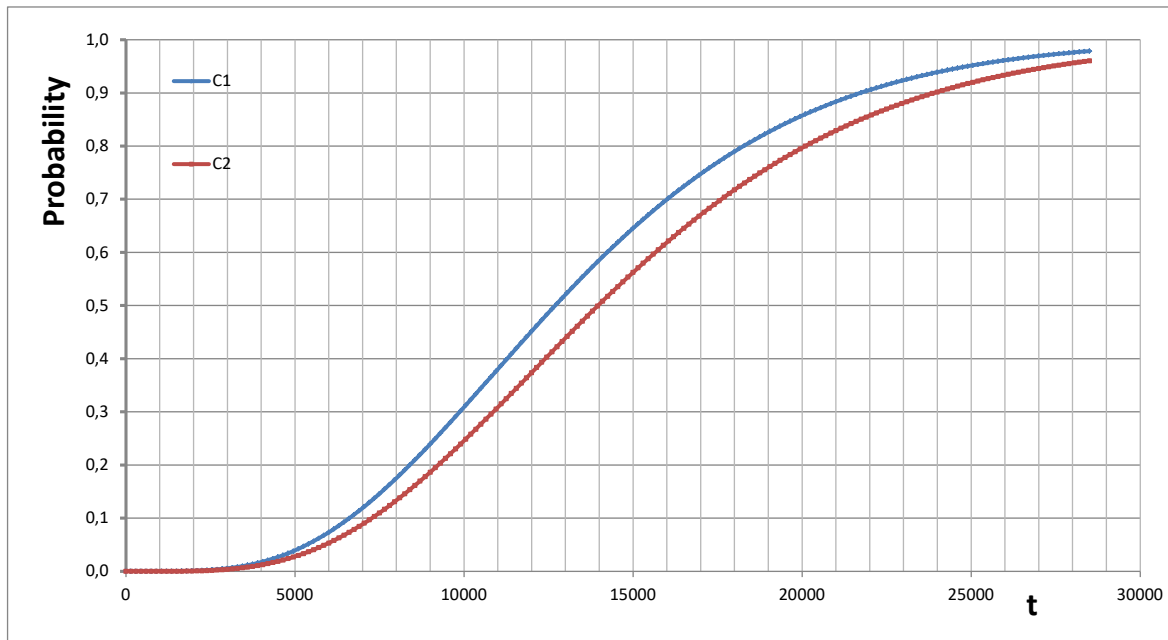


Figure 9: The probability that “number of Long Downtimes” M , in the mission time $0 \dots t$, is $> N_{LD}$; case 1 and case 2

V. THE 3RD STEP: A SEMI-MARKOV PROCESS WITH CONSTANT FAILURE RATE AND GENERAL REPAIR RATE

Let's consider our system again, as depicted in the following flow graph.

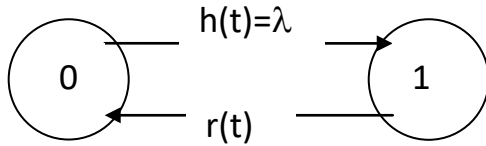


Figure 10: A 2-state system, with constant failure rate λ and variable repair rate $r(t)$

Now we consider that the failure is constant, $h(t)=\lambda$, while the repair rate is any positive function $r(t)$. We assume that the reliability goals are the same as in section 3.

We remind here that we found the integral equations for availability and using the method of Peano-Picard, we could derive the solution [here repeated for convenience]

$$A_0(t) = R(t) + \int_0^t m(r)R(t-r)dr \quad (16)$$

where the "intensity" $m(t)$ is given by

$$m(t) = z(t) + \int_0^t m(r)z(t-r)dr \quad (17)$$

and where the product $m(t)dt \cong$ probability that a cycle is completed in the interval $t \dots t+dt$.

The probability that the "number of Long Downtimes" M , in the mission time $0 \dots t$, is $> N_{LD}$ (and the supplier will pay a penalty P_{NLD}) is again [formula 26 repeated here]

$$P[M \geq N_{LD}] = 1 - \sum_{n=0}^{N_{LD}} \frac{(p\lambda t)^n}{n!} \exp(-p\lambda t) \quad (26)$$

where the probability p is obtained by the repair rate $r(t)$.

For this case 3, the repair rate $r(t)$ is of a Weibull distribution with $\beta_{\text{repair}}=2$

We want here to find the probability $LD(x|t)$, that the system is still in the state 1 [downstate] for a time x , given that the system entered state 1 at time t ; we name $LD(x|t)$ "Long Downtime Complementary Distribution".

As per F. Galetto, vol. 1, page 170, we can write the following equation (similar to 16)

$$LD(x|t) = \int_x^{t+x} m(t+x-y)\bar{G}(y)dy \quad (33)$$

When downtime D is $> x$ (a stated value, named "Long Downtime") the supplier will pay a penalty P_D

To prove (32), now we argue as in section 4: it is easily seen that after two cycles the Availability and the cycling intensity are almost constant; therefore, if $t > 2$ MTBF, we have

$$LD(x|t) \cong \int_x^{t+x} m(t+x-y)\bar{G}(y)dy = \frac{\int_x^{t+x} \bar{G}(y)dy}{MTBF} \quad (34)$$

that is, using (10),

$$LD(x|t) \cong \frac{MTTR(t+x) - MTTR(x)}{MTBF} \quad (35)$$

where $MTTR(t)$ is the Mean Time To Repair, related to the interval $0 \dots t$.

For $x \rightarrow \infty$, one gets $LD(x|t) \rightarrow 0$, as it must be. For $t \rightarrow \infty$, one gets $LD(x|t) \rightarrow MDT/MTBF$, as it must be. To consider both the number of failures and the long downtime we need the probability $LD(x|t, n)$: the probability that, in the mission interval $0 \dots t$, the downtime is long x , given that the number of failures is n , is the formula (36)

$$LD(x|t, n) = \int_x^{t+x} f_n(t+x-y)\bar{G}(y)dy \quad (36)$$

where $f_n(t)dt = P[t < T_n < t+dt]$ is the probability that the n -th failure happens in the interval $t \dots t+dt$ (T_n is the "time to the n -th failure"). The relationship between $f_{n+1}(t)$ and $f_n(t)$ [where $f_1(t)=f(t)$]

$$f_{n+1}(t) = f(t) + \int_0^t f_n(r)z(t-r)dr \quad (37)$$

Summing over all the number of failures from (37) one gets (33).

$LD(x|t, N_i+1)$ provides the probability that, in the mission interval $0 \dots t$, the downtime is long x and the number of failures is $>$ maximum allowed number N_i ; the supplier will pay a penalty $P_i + P_D$.

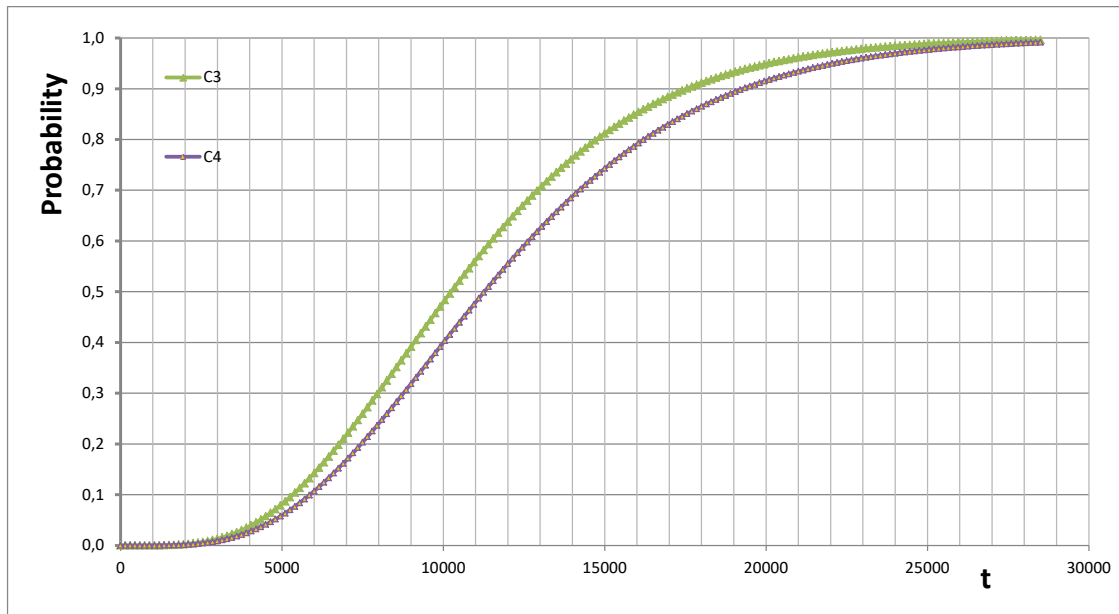


Figure 11: The probability that “number of Long Downtimes” M , in the mission time $0 \leq t \leq T$, is $> N_{LD}$; case 3 and case 4

Using the very *strong assumption* $\mu \gg \lambda$ (the downtimes are very short and t is the total up time) it is very easy to compute

$$LD(x|t, 1) = \int_x^{x+t} f(t+x-y)\bar{G}(y)dy \quad (38)$$

Similarly, $LD(x|t, 2), \dots$ Any $LD(x|t, n)$ is related to (27) via the probability p , given by the Weibull.

The cases 3 and 4 are similar to the ones 1 and 2, with the difference of the uses of a Weibull repair distribution.

VI. THE 4TH STEP: A GENERAL SEMI-MARKOV PROCESS

Let’s consider our system again, as depicted in the following flow graph.

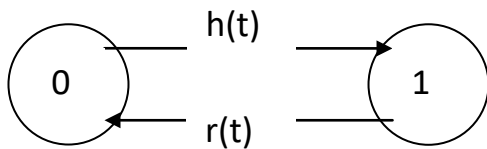


Figure 12: A 2-state system, renewable, with variable both failure rate $h(t)$ and repair rate $r(t)$

Now we consider that the failure is any positive function $h(t)$ and the repair rate is any positive function $r(t)$, both related to their Weibull distribution; we also assume that *the system is renewed* at any entrance into the state 0.

We assume that the reliability goals are the same as in section 3.

In the hypothesis of a general Semi-Markov process, the formulae are the same as those of section 5 (we do not repeat them here).

We see the probability in figure 13.

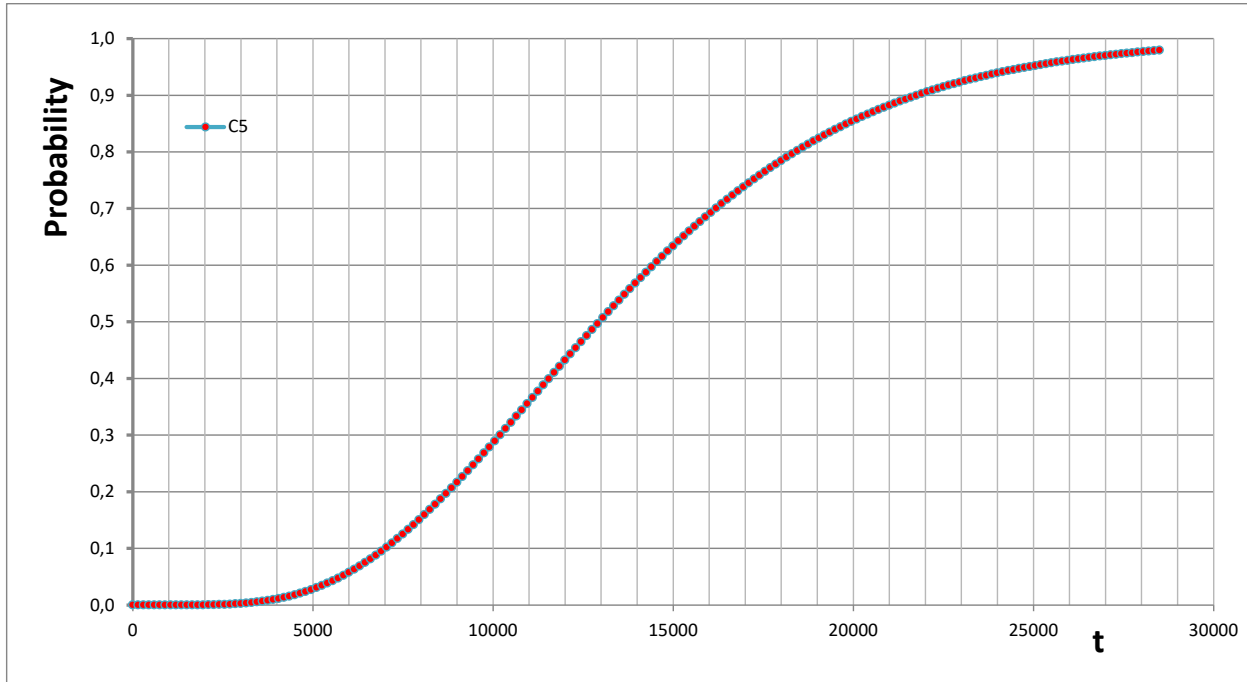


Figure 13: The probability that “number of Long Downtimes” M , in the mission time $0 \leq t$, is $> N_{LD}$; case 5

We see that the probability $P[M > N_{LD}]$ increases with the length t of the “mission interval”: as t increases, the “Long Downtimes” becomes more and more probable (as anybody should expect).

It is quite interesting to notice that the most general case 5 has time behavior “very similar” to the case 1: this is because the Steady State Availability A_{SS} is the same value.

To appreciate the differences between the various cases, see figure 14.

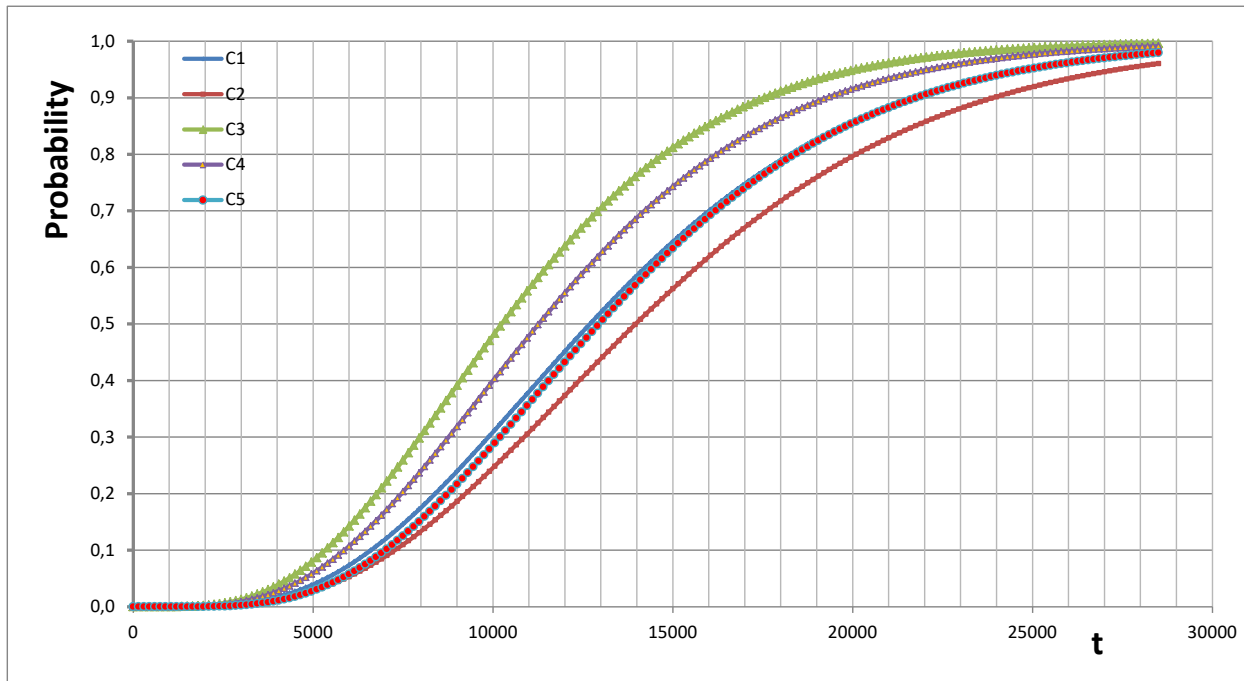


Figure 14: Probability that “number of Long Downtimes” M , in the mission time $0 \leq t$, is $> N_{LD}$; cases 1-5

VII. THE COST INSERTED IN THE GENERAL SEMI-MARKOV PROCESS

Let's consider our system again, as depicted in FIGURE 12.

Now we generate a model where the costs are inserted in the general equation of the model.

Let's indicate with the symbols $b_{ik}(t)dt$ the transition probability from state i to state k (either 0 or 1, or vice versa) in the interval $t-t+dt$, p_{ik} the steady transition probability from state i to state k , m_i the mean time that the system stays in state i before making a transition, $e_{ik}(0, s)$ the earning [or cost] of the system due the transition from state i to state k for the interval $0-s$, $d_{ik}(s)$ the earning [or a cost] of the system due the transition from state i to state k at the instant s , $v_i(t)$ the total expected profit [or cost] of the system for the interval $0-t$ (mission time), if the system starts in state i at time 0. We define $r_i(t)$ the expected reward (or cost) of the system related to state i , due to its transitions in the interval $0-t$

$$r_i(t) = \sum_{k=0}^1 \int_0^t b_{ik}(s) [e_{ik}(0, s) + d_{ik}(s)] ds$$

If the system makes its 1st transition out of the state i , before the instant t , it earns a profit

$$\sum_{k=0}^1 r_i(t) + \int_0^t b_{ik}(s) v_k(t-s) ds$$

If the system makes its 1st transition out of the state i , after the instant t , it earns a profit

$$\sum_{k=0}^1 \overline{W}_k(t) p_{ik} e_{ik}(0, t)$$

Putting all together, we have the system of integral equations [notice the similarity with what done before for reliability] of the expected reward (or cost) of the system in the mission interval

$$v_i(t) = \sum_{k=0}^1 \int_0^t [e_{ik}(0, s) + d_{ik}(s) + v_k(t-s)] b_{ik}(s) ds + \sum_{k=0}^1 \overline{W}_k(t) p_{ik} e_{ik}(0, t) \quad (39)$$

The general model (with $n+1$ states) was devised by the author and presented at an EOQC Conference [XXI EOQC (European Organisation for Quality Control)] held in Varna (Bulgaria), 1977, with a paper titled *CLAUDIA Cost and Life Analysis via Uptime and Downtime Integral Approach*.

In our case $d_{01}(s)=1$ (for the failures) and $e_{01}(0, t)=0$, while $d_{10}(s)=0$ and $e_{10}(0, s)=H(s-x)$ (for the long downtimes $>x$), where $H(t-x)$ is the Heaviside function.

$$\begin{aligned} v_0(t) &= \int_0^t b_{01}(s) [1 + v_1(t-s)] ds \\ &= W_0(t) + \int_0^t b_{01}(s) v_1(t-s) ds \\ v_1(t) &= \overline{W}_1(t) H(t-x) \\ &+ \int_0^t b_{10}(s) \{H(s-x) + v_0(t-s)\} ds \\ &= \overline{W}_1(t) H(t-x) + W_1(t) - W_1(x) \\ &+ \int_0^t b_{10}(s) v_0(t-s) ds \end{aligned}$$

The initial conditions:

$$v_0(t) = 0$$

$$v_1(t) = 0$$

These equations can be easily solved, in the case of exponential distributions.

As a matter of fact, in such a case,

$$\begin{aligned} v_0(t) &= 1 - e^{-\lambda t} + \int_0^t \lambda e^{-\lambda s} v_1(t-s) ds \\ &= 1 - e^{-\lambda t} + \lambda e^{-\lambda t} \int_0^t e^{\lambda s} v_1(s) ds \end{aligned}$$

$$\begin{aligned} v_1(t) &= e^{-\mu t} H(t-x) + (1 - e^{-\mu t}) - (1 - e^{-\mu x}) \\ &+ \int_0^t \mu e^{-\mu s} v_0(t-s) ds \\ &= e^{-\mu t} H(t-x) - e^{-\mu t} + e^{-\mu x} \\ &+ \int_0^t \mu e^{-\mu s} v_0(t-s) ds \\ &= e^{-\mu t} H(t-x) - e^{-\mu t} + e^{-\mu x} \\ &+ \mu e^{-\mu t} \int_0^t e^{\mu s} v_0(t-s) ds \end{aligned}$$

From these we can find two differential equations

$$v_0'(t) + \lambda v_0(t) = \lambda v_1(t) + \lambda$$

$$v_1'(t) + \mu v_1(t) = \mu v_0(t) + e^{-\mu x} + \mu$$

that are written in matrix form

$$v'(t) = Av(t) + \begin{bmatrix} \lambda \\ \mu + e^{-\mu x} \end{bmatrix} \quad (40)$$

with

$$A = \begin{bmatrix} -\lambda & \lambda \\ \mu & -\mu \end{bmatrix} \quad (41)$$

The solution is

$$v(t) = e^{At} \int_0^t e^{-As} \begin{bmatrix} \lambda \\ \mu + e^{-\mu x} \end{bmatrix} ds \quad (42)$$

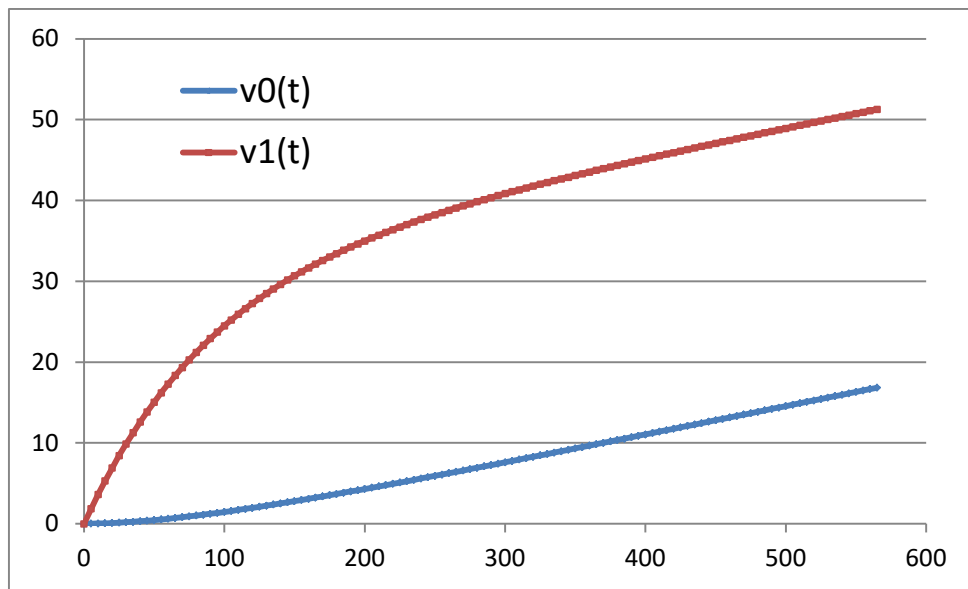


Figure 15: The mean number of “Long Downtimes” and of failures versus t, the mission time 0→t

We can easily find the difference between the two components of the vector $v(t)$. The difference becomes constant for $t \rightarrow \infty$. The solution of (42) is increasing, linearly for $t \rightarrow \infty$ (see figure 15)

$$v_0(t) = \frac{\lambda(2\mu + e^{-\mu x})}{\lambda + \mu} t - \frac{\{\mu + e^{-\mu x} - \lambda\}\lambda}{(\lambda + \mu)^2} [1 - e^{-(\lambda + \mu)t}] \quad (43)$$

$$v_1(t) = \frac{\lambda(2\mu + e^{-\mu x})}{\lambda + \mu} t + \frac{\{\mu + e^{-\mu x} - \lambda\}\mu}{(\lambda + \mu)^2} [1 - e^{-(\lambda + \mu)t}] \quad (44)$$

We see that the difference between the two curves becomes constant.

The type of behavior of the two curves, devised for constant failure and repair rates, is similar for variable rates; the proof can be found in the paper *CLAUDIA Cost and Life Analysis via Uptime and Downtime Integral Approach*.

VIII. CONCLUSION

Any action speaks louder than words: professors teaching wrong ideas do a lot of harm to their students and the whole Society, although they are *all graduated CUM LAUDE*, with Ph.D. (*CUM LAUDE*), very appreciated by their followers (with their “likes”) and have high scores with the informetric indexes (h-index, RG-index, s-index, and so on). [2, 10-21]

We showed that Theory is needed to solve correctly the problem of evaluating the cost of failures and downtimes in a very simple 2-state system, where requirements on the number of failures N_f , on the length of downtime x , and the maximum number of Long Downtimes N_{LD} are fixed in a supply contract of the system; if the supplier does not meet the stipulated goals, he must pay the penalty. We used the SPQR Principle and approach [1].

The method can be extended to more complex systems.

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APPENDIX "SCIENTIFICITY"

This appendix about Scientificity is derived from many sources of Fausto Galetto's thinking. It is given here as a summary.

We also show four cases of lack of Scientificity.

Here we want to provide the reader with some ideas about the need of the Scientific Attitude that all the teachers and managers must have: it starts with two Premises and one Entailment.

1st Premise: Ever since he was a young student, at the secondary school, Fausto Galetto was fond of understanding the matters he was studying: understanding for learning was his credo (φιλομαθησυσνημι); for all his life he was keeping this attitude, studying more than one ton of pages: as manager and as consultant he studied several methods invented by professors, but never he used the (many) wrong ones; on the contrary, he has been devising many original methods needed for solving the problems of the Companies he worked for, and presenting them at international conferences [where he met many bad divulggers, also professors "ASQC certified quality auditors" or "Master Black Belt (Six Sigma) Experts"]; after 25 years of applications and experience, he became professor, with a dream "improve the future managers (students) quality": the incompetents he met since then grew dramatically (also with documents. F. Galetto got from ERASMUS students (Fijiu Antony et al., 2001, Sarin S. 1997).

2nd Premise: "The wealth of nations depends increasingly on the quality of managers." (A. Jay [3]) and the fact that "Universities grow the future managers." (F. Galetto)

Entailment: due to that, the author with this paper will try, again, to provide the important consequent message: let us, all of us, be scientific in all Universities, that is, let us all use our rationality. "What I want to teach is: to pass from a hidden non-sense to a non-sense clear." (L. Wittgenstein). End

We have been seeing and we are still seeing the consequences of the lack of Scientificity during the Covid-19 pandemic... Remember Deming's ideas.

"In my university studies ..., in most of the cases, it seemed that students were asked simply to regurgitate at the exams what they had swallowed during the courses." M. Gell-Mann "The Quark and the Jaguar..." [1994] } . Some of those students later could have become researchers and then professors, writing "scientific" papers and books ... For these last, another statement of the Nobel Prize M. Gell-Mann is relevant: "Once that such a misunderstanding has taken place in the publication, it tends to become perpetual, because the various authors simply copy one each other.".....

similar to "Imitatores, servumpecus" [Horatius, 18 B.C.] and "Gravior et validio rest decemvirorum bonorumsententia quam to tiusmultitudinis imperitiae" [Cicero]. When they teach, "The result is that hundreds of people are learning what is wrong. I make this statement on the basis of experience, seeing every day the devastating effects of incompetent teaching and faulty applications." [Deming (1986)], because those professors are unable to practice maieutic [μαιευτικήτεχνη], the way used by Socrates for teaching [the same was for Galileo Galilei in his "Dialogue on the Two Chief World Systems"]. Paraphrasing P. B. Crosby, in his book "Quality is free", we could say "Professors may or may not realize what has to be done to achieve quality. Or worse, they may feel, mistakenly, that they do understand what has to be done. Those types can cause the most harm." What do have in common Crosby, Deming and Gell-Mann statements? The fact that professors and students betray an important characteristic of human beings: rationality [the "Adult state" of E. Berne]. Human beings are driven by curiosity that demands that we ask questions ("why?. ... , why?") and we try to put things in order ("this is connected with that"): curiosity is one of the best ways to learn, but "learning does not mean understanding"; only twenty-six centuries ago, in Greece, people began to have the idea that the "world" could be "understood rationally", overcoming the religious myths: they were sceptic [σκεπτομαι=to observe, to investigate] and critic [κρινω=to judge]: then and there a new kind of knowledge arose, the "rational knowledge".

These ideas gave rise to the SPQR Principle and approach [1]

Till today, after so long time, we still do not use appropriately our brain! A peculiar, stupid and terrific non-sense! During his deep and long experience of Managing and Teaching (more than 40 years), F. Galetto always had the opportunity of verifying the truth of Crosby, Deming and Gell-Mann statements.

To understand each other we need to define the word "scientific".

A document (paper or book) is "scientific" if it "scientifically (i.e. with "scientific method") deals with matters concerning science (or science principles, or science rules)". Therefore to be "scientific" a paper must both concern "science matters" and be in accordance with the "scientific method".

The word "science" is derived from the Latin word "scire" (to know for certain) {derived from the Greek words μαθησις, επιστημη, meaning learning and knowledge, which, at that time, were very superior to "opinion" [δοξα], while today opinion of many is considered better than the knowledge of very few!}; think to the recent behaviour of people, they look for getting many "likes" in the web!!! Knowledge is strongly related to "logic reasoning" [λογικουζουζ], as it was, for ages, for Euclid, whose Geometry was considered the

best model of "scientificity". Common (good) sense is not science! A lot of "likes" in the web is not science! Common sense does not look for "understanding", while science looks for "understanding"! "Understanding" is related to "intelligence" (from the Latin verb "intelligere" ([intus+legere. to read into]: "intelligeutcredas" i.e. understand to believe. Unfortunately "none so deaf as those that won't hear".

Let us give an example, the Pythagoras Theorem (figure 16):

"In a right triangle, the square of the length of the hypotenuse equals the sum of the squares of the lengths of the other two sides." Is this statement scientific? It could be scientific because it concerns the science of Geometry and it can be proven true by mathematical arguments. It is not-scientific because we did not specify that we were dealing with the "Euclidean Geometry" (based, among others, on the "parallel axiom": from this only, one can derive that the sum of the interior angles of a triangle is always π): we did not deal "scientifically" with the axioms; we assumed them implicitly.

So we see that "scientificity" is present only if the set of statements (concerning a given "system") are non-contradictory and deducible from stated principles (as the rules of Logic and the Axioms).

Let us give another example, the 2nd law of Mechanics (figure 16):

"The force and the acceleration of a body are proportional vectors: $F=ma$, (m is the mass of the body)". Is this statement scientific? It could be scientific because it concerns the science of Mechanics and it can be proven "true" by well-designed experiments. It is not-scientific because we did not specify that we were dealing with "frames of reference moving relatively one to another with constant velocity" [inertial frames (with the so called "Galilean Relativity": the laws of Physics look the same for inertial systems)] and that the speed involved was not comparable with the "speed of light in the vacuum [that is the same for all observers]" (as proved by the Michelson-Morley experiment: in the Special Relativity Theory, $F=d(mv)/dt$ is true, not $F=ma!$) and not involving atomic or subatomic particles. We did not deal "scientifically" with the hypotheses; we assumed them implicitly. From the laws of Special Relativity we can derive *logically* the conservation laws of momentum and of energy, as could Newton for the "Galilean Relativity". For atomic or subatomic particles "quantum Mechanics" is needed (with Schrödinger equation as fundamental law).

So we see that "scientificity" is present only if the set of statements (concerning a given "system") do not contradict the observed data, collected through well designed experiments ["scientific" experiments]: only in the XVII century, due to Galilei, Descartes, Newton, ... we learned that. Since that time only, science could really grow.

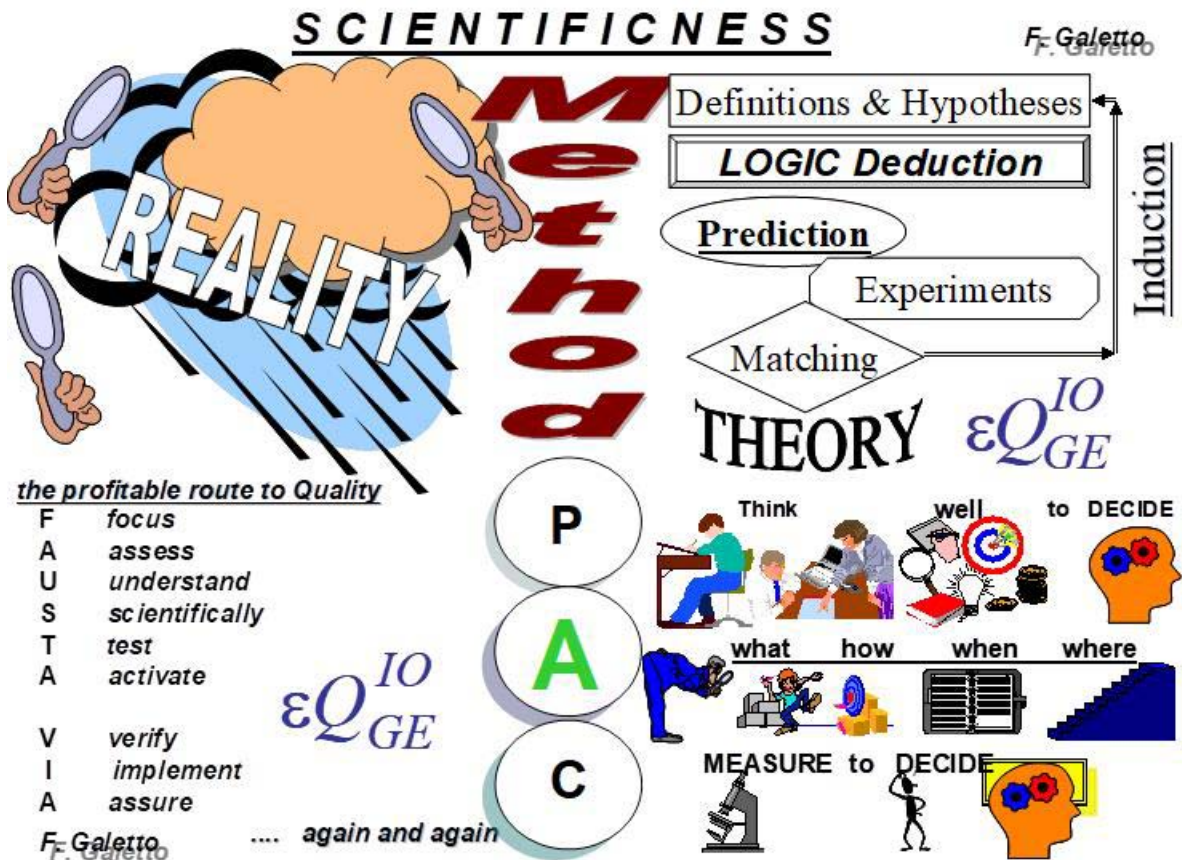


Figure 16: Scientificity and Theory

When we start trying to learn something, generally, we are in the “clouds”; reality (and truth) is hidden by the clouds of our ignorance, the clouds of the data, the clouds of our misconceptions, the clouds of our prejudices; to understand the phenomena we need to find out the reality from the clouds: we make hypotheses, then we deduct logically some consequences, predicting the results of experiments: if predictions and experimental data do match then we “confirm” our idea and if many other are able to check our findings we get a theory. To generate a theory we need Methods. Eric Berne, the psychologist father of “Transactional Analysis”, stated that everybody interacts with other people through three states P, A, C [Parent, Adult, Child, (not connected with our age, fig. 16)]: the Adult state is the one that looks for reality, makes questions, considers the data, analyses objectively the data, draws conclusions and takes logic decisions, coherent with the data, methodically. Theory [θεωρία] comes from the Adult state! Methods [μεθοδος from μετα+οδος = the way through (which one finds out...)] used to generate a Theory come from the Adult state!

People who take for granted that the truth depends on “Ipse dixit” [αυτοξερα, “he said that” (F. Bass “said that”, and published his ideas on a very important Management Magazine, “Management Science”)], behave with the Parent state. People who get

upset if one finds their errors and they do not consider them [“we are many and so we are right”, they say!] behave with the Child state. [see the books of the Palo Alto group]

To find scientifically the truth (out of the clouds) you must Focus on the problem, Assess where you are (with previous data and knowledge), Understand Scientifically the message in the data and find consequences that confirm (or disprove) your predictions, Scientifically design Test for confirmation (or disproval) and then Activate to make the Tests. If you and others Verify you prediction, anybody can Implement actions and Assure that the results are scientific (FAUSTA VIA): all of us then have a theory and scientificity is there (F. Galetto)

From the above two examples it is important to realise that when two people want to verbally communicate, they must have some common concepts, they agree upon, in order to transfer information and ideas between each other; this is a prerequisite, if they want to understand each other: what is true for them, what is their “conventional” meaning of the words they use, which are the rules to deduce statements (Theses) from other statements (Hypotheses and “previous” Theses): rigour is needed for science, not opinions.

Many people must apply *Metanoia* [μετανοια = change their mind (to understand)] to find the truth.

Here we accept the rules of Logic, the *deductive* Logic, where the premises of a valid argument contain the conclusion, and the truth of the conclusion follows from the truth of the premises with certainty: any well-formed sentence is either true or false. We define as *Theorem* “a statement that is proven true by reasoning, according to the rules of Logic”; we must therefore define the term *True*: “something” (statement, concept, idea, sentence, proposition) is true when there is *correspondence* between the “something” and the facts, situations or state of affairs that verify it; the *truth* is a relation of *coherence* between a thesis and the hypotheses. Logical validity is a relationship between the premises and the conclusion such that if the premises are true then the conclusion is true. The validity of an argument should be distinguished from the truth of the conclusion (based on the premises).

This kind of truth is found in mathematics.

Human beings evolved because they were able to develop their knowledge from inside (the *deductive* logic, with analytic statements) and from outside, the external world, (the *inductive* logic, with synthetic statements), in any case using their intelligence; the *inductive* logic is such that the premises are evidence for the conclusion, but the truth of the conclusion follows from the truth of the evidence only with a certain probability, provided the way of reasoning is correct.

The scientific knowledge is such that any valid knowledge claim must be verifiable in experience and built up both through the *inductive* logic (with its synthetic statements) and the *deductive* logic (with its analytic statements); in any case, a clear distinction must be maintained between analytic and synthetic statements.

This was the attitude of Galileo Galilei in his studies of falling bodies. At first time, he formulated the tentative hypothesis that “the speed attained by a falling body is directly proportional to the distance traversed”; then he deduced from his hypothesis the conclusion that objects falling equal distances require the same amount of elapsed time. After “Gedanken Experimenten”, Designed Experiments made clear that this was a false conclusion: hence, logically, the first hypothesis had to be false. Therefore, Galileo framed a new hypothesis: “the speed attained is directly proportional to the time elapsed”. From this, he was able to deduce that the distance traversed by a falling object was proportional to the square of the time elapsed; through Designed Experiments, by rolling balls down an inclined plane, he was able to verify experimentally his thesis (it was the first formulation of the 2nd law of Mechanics).

Such agreement of a conclusion with an actual observation does not itself prove the correctness of the hypothesis from which the conclusion is derived. It simply renders that premise much more plausible.

For rational people (like were the ancient Greeks) the criticism [$\kappa\rho\iota\nu\omega$ = to judge] is hoped for, because it permits improvement: asking questions, debating and looking for answers improves our understanding: we do not know the truth, but we can look for it and be able to find it, with our brain; to judge we need criteria [$\kappa\rho\iota\tau\epsilon\rho\iota\omicron\nu$]. In this search, Mathematics [note $\mu\alpha\theta\eta\sigma\iota\varsigma$] and Logic can help us a lot: Mathematics and Logic are the languages that Rational Managers must know! Proposing the criterion of testability, or falsifiability, for scientific validity, Popper emphasized the hypothetic-deductive character of science. Scientific theories are hypotheses from which can be deduced statements testable by observation; if the appropriate experimental observations falsify these statements, the hypothesis is refused. If a hypothesis survives efforts to falsify it, it may be tentatively accepted. No scientific theory, however, can be conclusively established. A “theory” that is falsified, is no longer scientific.

“Good theories” are such that they complete previous “good” theories, in accordance with the collected new data.

A good example of that is Bell's Inequality. In physics, this inequality was used to show that a class of theories that were intended to “complete” quantum mechanics, namely local hidden variable theories, are in fact inconsistent with quantum mechanics; quantum mechanics typically predicts probabilities, not certainties, for the outcomes of measurements. Albert Einstein [one of the greatest scientists] stated that quantum mechanics was incomplete, and that there must exist “hidden” variables that would make possible definite predictions. In 1964, J. S. Bell proved that all local hidden variable theories are inconsistent with quantum mechanics, first through a “Gedanken Experiment” and Logic, and later through Designed Experiments. Also, the great scientist, A. Einstein, was wrong in this case: his idea was falsified. We see then that the ultimate test of the validity of a scientific hypothesis is its *consistency* with the totality of other aspects of the scientific framework. This inner consistency constitutes the basis for the concept of causality in science, according to which every effect is assumed to be linked with a cause.

The scientific community as a whole must judge [$\kappa\rho\iota\nu\omega$] the work of its members by the objectivity and the rigour with which that work has been conducted; in this way the scientific method should prevail.

In any case, the scientific community must remember: Any statement (or method) that is falsified, is no longer scientific.

Here we assume that the subject of a paper is concerning a science (like Mathematics, Statistics, Probability, Quality Methods, Management, ...); therefore to judge [$\kappa\rho\iota\nu\omega$] if a paper is scientific we have

to look at the “scientific method”: if the “scientific method” is present, i.e. the conclusions (statements) in the paper follow logically from the hypotheses, we shall consider the paper scientific; on the contrary, if there are conclusions (statements) in the paper that do not follow logically from the hypotheses, we shall not consider the paper scientific: a wrong conclusion (statement) is not scientific.

"To understand that an answer is wrong you don't need exceptional intelligence, but to understand that is wrong a question one needs a creative mind." (A. Jay). "Intelligencecredas".

That was the way the author dealt with his students (in Universities, in Companies Courses, in Mater's Lessons,...)

Right questions, with right methods, have to be asked to “nature”. "Intelligencecredas".

It is easy to show that a paper, a book, a method, is not scientific: it is sufficient to find an example that proves the wrongness of the conclusion. When there are formulas in a paper, it is not necessary to find the right formula to prove that a formula is wrong: an example is enough; to prove that a formula is wrong, one needs only intelligence; on the contrary, to find the right formula, that substitutes the wrong one, you need

both intelligence and ingenuity. I will use only intelligence and I will not give any proof of my ingenuity: this paper is for intelligence ...

For example, it's well known (from Algebra, Newton identities) that the coefficients and the roots of any algebraic equation are related: it's easy to prove that $\pm\sqrt{-c/a}$ is not the solution (even if you do not know the right solution) of the parabolic equation $ax^2 + bx + c = 0$, because the system $x_1 + x_2 = -b/a$, $x_1x_2 = c/a$ is not satisfied (x_1 and x_2 are the roots).

The literature on “Quality” matters is rapidly expanding. Unfortunately, nobody, but the author, as far as he knows, [he thanks any person that will send him the names of people who take care ...], takes care of the "Quality of Quality Methods used for making Quality" (of product, processes and services). "Intelligencecredas".

Let's give two others cases of lack of Scientificity.

See the following excerpts (figures 17-18, excerpts 1 and 2) taken from a book on reliability; they refer to the system we have analysed previously [$w(t)$ is our $m(t)$].

we have the following simultaneous identity:

$$\left. \begin{aligned} w(t) &= f(t) + \int_0^t f(t-u)v(u) du \\ v(t) &= \int_0^t g(t-u)w(u) du \end{aligned} \right\} \quad (4.64)$$

The unconditional failure intensity $w(t)$ and the repair intensity $v(t)$ are calculated by an iterative numerical integration of (4.64) when densities $f(t)$ and $g(t)$ are given. If a rigorous, analytical solution is required, Laplace transforms can be used.

Figure 17: Excerpt 1 from a book...



We now differentiate the fundamental identity (4.64):

$$\left. \begin{aligned} \frac{w(t)}{dt} &= f'(t) + f(0)v(t) + \int_0^t f'(t-u)v(u) du \\ \frac{v(t)}{dt} &= g(0)w(t) + \int_0^t g'(t-u)w(u) du \end{aligned} \right\} \quad (4.124)$$

where $f'(t)$ and $g'(t)$ are defined by

$$f'(t) = \frac{f(t)}{dt}, \quad g'(t) = \frac{g(t)}{dt} \quad (4.125)$$

The differential equation (4.124) is now integrated, yielding the results shown in Fig. 4.23.

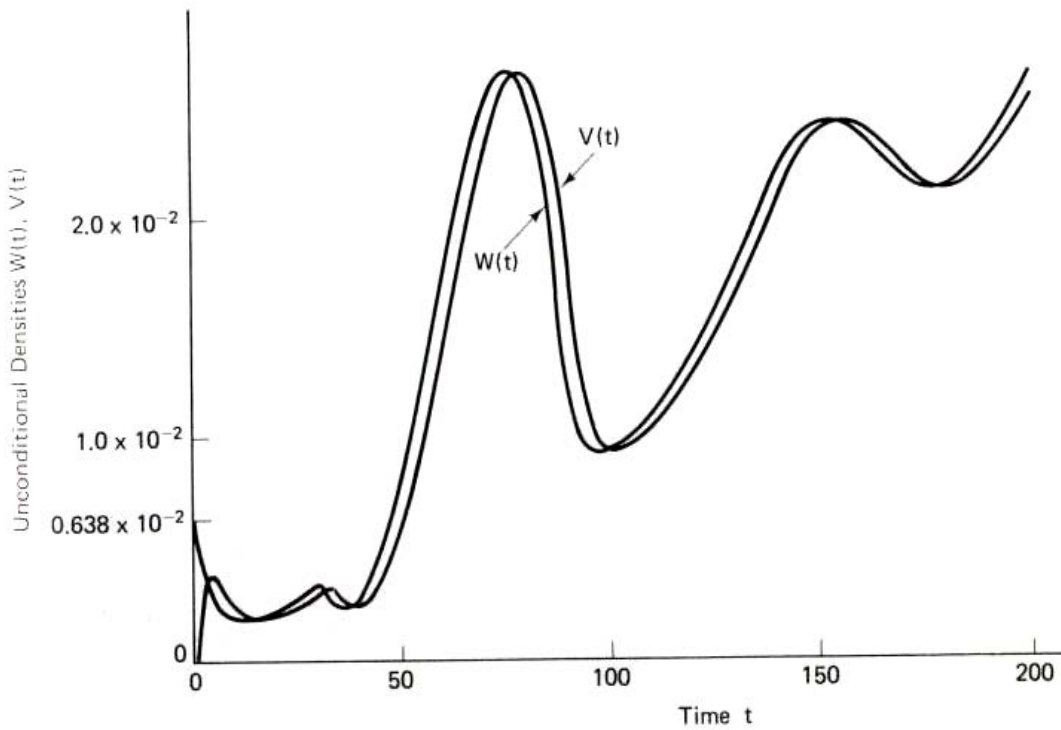


Figure 4.23. Result of integration of (4.124).

Figure 18: Excerpt 2 (the curve W(t) is M(t) in our formulae) from a book...



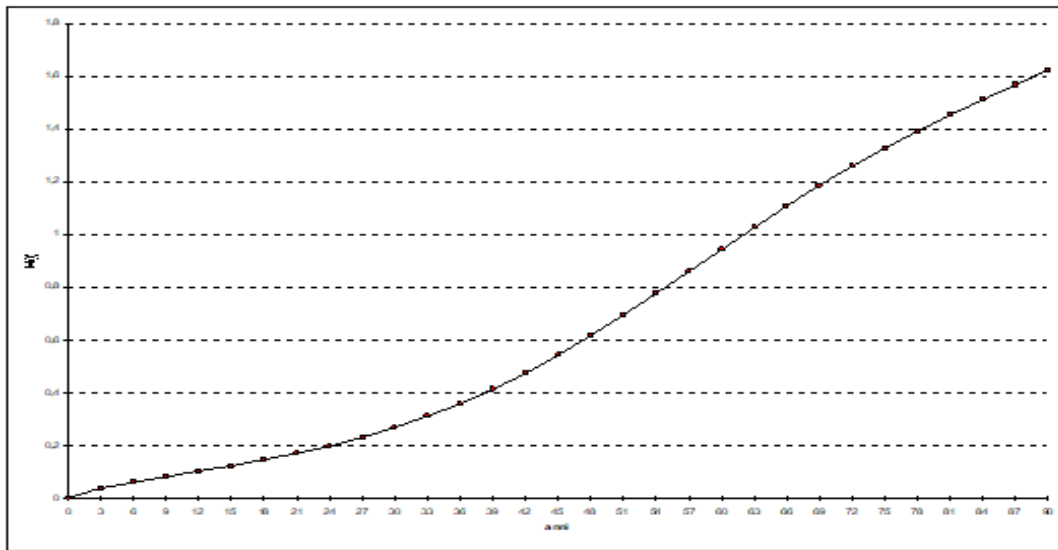


Figure 19: A typical behaviour of the curve $M(t)$. $M(t)$ [corresponding to $W(t)$ of excerpt 2] obtained via the Reliability Integral Theory

NOTICE the differentiation, FIRST, and the integration, SECOND!

Notice the symbols in the formula 4.124 and 4.125 (fig. 18)! Had the authors studied Mathematics?

WHAT are they for? Integration is the “opposite” operation of differentiation!

One sees very clearly that $W(t)$ of excerpt 2 (the curve $W(t)$ is $M(t)$ in our formulae) does not have the behaviour that it MUST have according the reliability theory; the following graph shows the curve $M(t)$ obtained via the Reliability Integral Theory.

The curves $W(t)$ and $M(t)$ are very different: only $M(t)$ is according to the THEORY.

It is obvious that to compute correctly the cost of failures, of downtimes, of maintenance and of spare parts management one MUST compute correctly the function $M(t)$. [23, 30, 31]

Will professors understand?

None so deaf as he does not want to hear.....

Wrong teaching: help or hoax for Quality?

HOAX, if people (professors, managers, consultants, ...) do not use their own brain !!!!!

Let’s now consider another case related to the T Charts.

It is taken from the paper “Minitab T Charts and Quality Decisions”, submitted to a Journal, in 2020.

The T Charts are used for “rare events”: they are Individual Control Charts with Exponentially or Weibull distributed data.

Here we deal with the problem by considering Example 7.6 found in the Montgomery book [37]; he writes “A chemical engineer wants to set up a control chart for monitoring the occurrence of failures of an important valve. She has decided to use the number of hours between failures as the variable to monitor”. Here are the data (exponentially distributed), named *lifetime*; (we used Minitab 19 to see the arising problems):

Table 1: Lifetime data (from Montgomery)

286	948	536	124	816	729	4	143	431	8
2837	596	81	227	603	492	1199	1214	2831	96

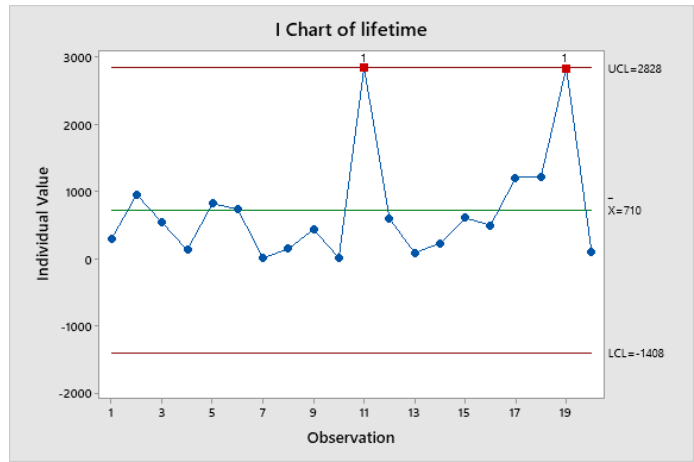
Since the data are few (20) and exponentially distributed one cannot use the usual formulae used for Normally distributed data. If one would [wrongly] do use those formulae he would find the figure 20 (Minitab used). According to it, the “process is Out Of Control” (OOC): two points are “above” UCL. If we had considered the Moving Ranges, we should have that two other points would be OOC.

Using SixPack or JMP, we would have the same picture of the process.

Is this a true picture of the process? Perhaps these OOC depends on the formulae used!

If we act as Montgomery did and we transform the exponential data into Weibull data with form parameter $\beta=1/3.6$ (this ideas was copied by Montgomery from Nelson! This attitude of copying without knowledge is very general, as said by Deming, [4] “Management need to grow-up their knowledge because experience alone, without theory, teaches nothing what to do to make Quality” and “The result is that hundreds of people are learning what is wrong. I make this statement on the basis of experience, seeing every day the devastating effects of incompetent teaching and faulty applications.”)

Let be y_i the original (exponential) data and $x_i = y_i^{1/3.6}$ the transformed (Weibull) data; Montgomery uses the I-MR Chart where in the upper graph the individual x_i are plotted with their mean \bar{x} and control limits and in the lower graph the individual $MR_i = |x_i - x_{i+1}|$ are plotted with their mean \overline{MR} and control limits. [it is the same graph of Montgomery book]



Test Results for I Chart of lifetime

TEST 1. One point more than 3,00 standard deviations from center line.
 Test Failed at points: 11; 19

Figure 20: Individual chart of Montgomery data. Minitab 19 used (assuming...)

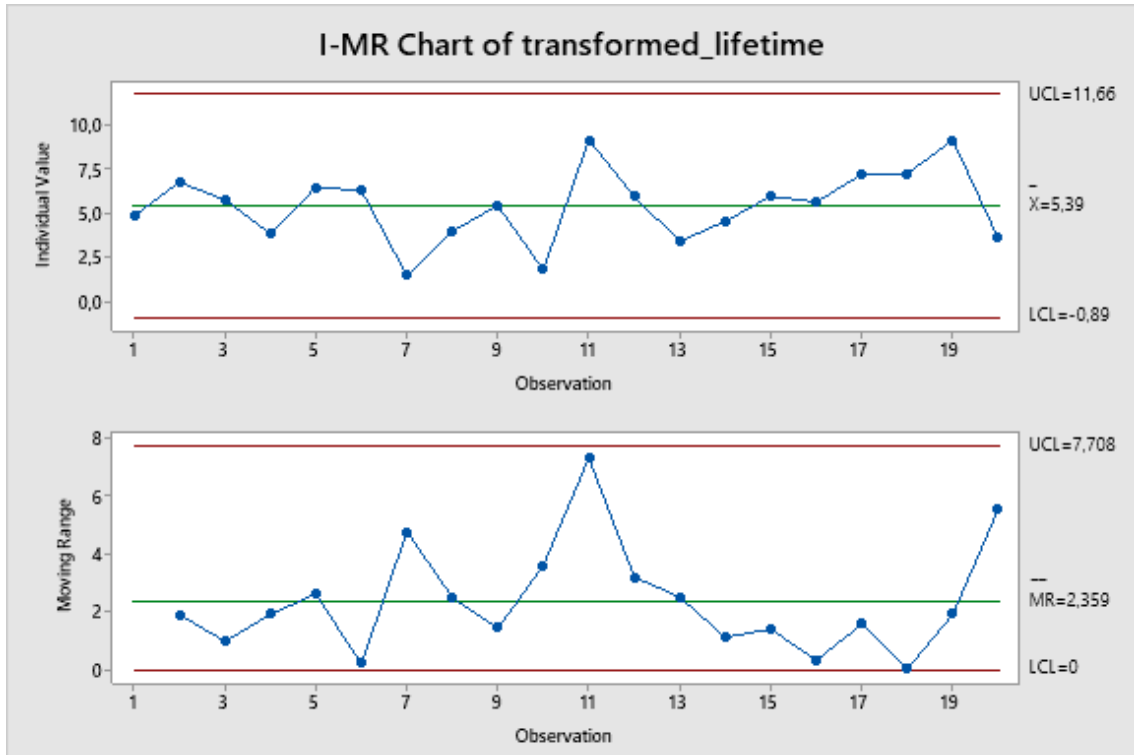


Figure 21: Individual and Moving Range chart of “transformed” Montgomery data (as suggested by Nelson). Minitab 19 used (F. Galetto)

According to figure 21, Montgomery says “Note that the control charts indicate a state of control, implying that the failure mechanism for this valve is constant. If a process change is made that improves the failure rate (such as a different type of maintenance action), then we would expect to see the mean time between failures get longer. This would result in points plotting above the upper control limit on the individuals control chart”.

Using SixPack or JMP we would have the same picture of the process (of the transformed data).

Then we have two contradictory conclusions! See both the figure 20 and the figure 21...

The Control Limits of figures 20 and 21 are computed as shown in a Quality Management Course by the professors members of the “Politecnico Quality Engineering Group (QEG)” (all graduated CUM LAUDE), in figure 22

Now we calculate the control limits of the \bar{X} -chart:

$$UCL_{\bar{X}} = \bar{\bar{X}} + 3 \cdot \sigma_{\bar{X}}$$

$$CL_{\bar{X}} = \bar{\bar{X}} = \frac{\sum_{i=1}^m \bar{x}_i}{m} \quad (\text{grand average, estimator of } \mu)$$

$$LCL_{\bar{X}} = \bar{\bar{X}} - 3 \cdot \sigma_{\bar{X}}$$

Since $\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$ (from statistics: central limit theorem)

Figure 22: Ideas given to students by professors of Quality Engineering Group (QEG)

Notice. Formulae for UCL, CL and LCL, in figure 22, hold only for Normally distributed data.... Hundred thousands of Master Black Belts, in the Six Sigma context, would use figure 22. Formula for $\sigma_{\bar{x}} = \sigma/\sqrt{n}$ is always valid for samples of size n; it has nothing to do with the "Central Limit Theorem".

Thousands Master Black Belts, in the Six Sigma context, would suggest using the Minitab Software and the "T Charts", assuming that T Charts are the good method to deal with "rare events". See the Minitab T Chart (figure 23).

Is this a true picture of the process? Perhaps this In Control depends on the formulae used!

Actually, the process is Out Of Control!The Minitab "T Charts" are wrong.

To understand completely the lack of Scientificity the reader can usefully read the paper *Hope for the Future: Overcoming the DEEP Ignorance on the CI (Confidence Intervals) and on the DOE (Design of Experiments, Science J. Applied Mathematics and Statistics.Vol. 3, No. 3, pp. 70-95*; the basic ideas, he can find there, are very useful.

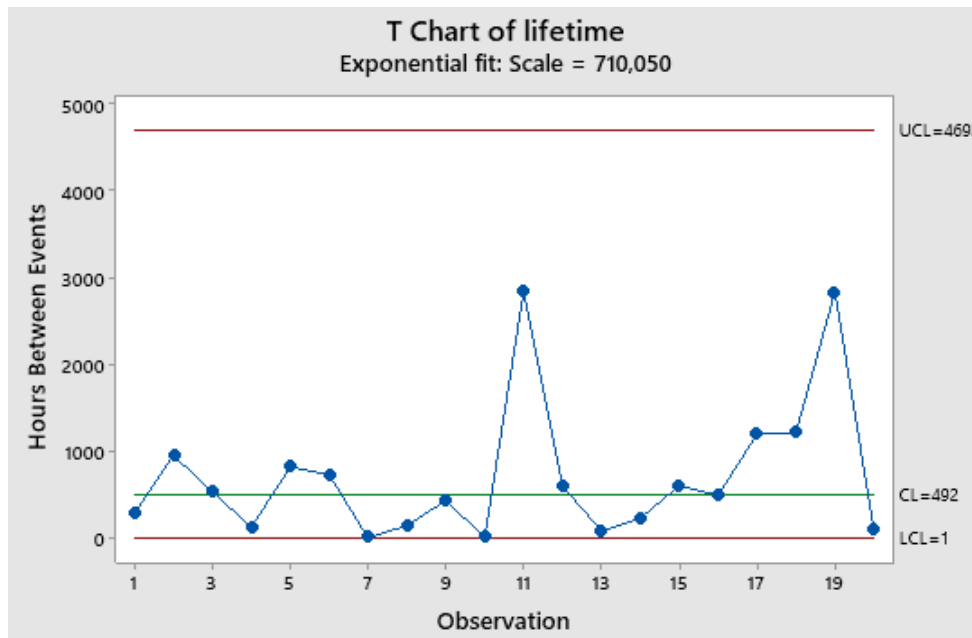


Figure 23: T Chart of Montgomery data. Minitab 19 used (F. Galetto)

Comparing the figure 23 with 24 it is very clear that, for the Montgomery data, the T Charts are quite different from the one of Figure 24 and the process is OOC (Out Of Control). Notice the plural "T Charts" because also the differences $|t_i - t_{i+1}|$ are exponentially distributed! Figure 24 is found by using the Reliability Integral Theory (RIT) [30, 31].

This proves the truth of Deming's statements "The result is that hundreds of people are learning what is wrong." "It is a hazard to copy", "It is necessary to understand the theory...."

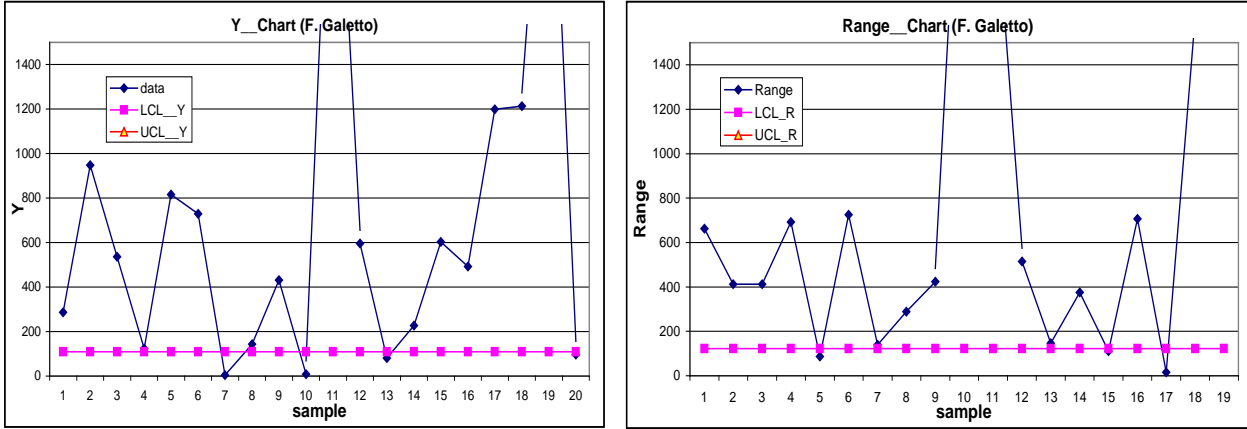


Figure 24: (F. Galetto) Scientific Control charts for valves [wrong control charts in Montgomery books]

We said before "The literature on "Quality" matters is rapidly expanding. Unfortunately, nobody, but the author, as far as he knows, [he thanks any person that will send him the names of people who take care ...], takes care of the "Quality of Quality Methods used for making Quality" (of product, processes and services). "Intelligeutcredas."

The author is eager to meet one of them, fond of Quality as he is. If this kind of person existed, he would have agreed that "facts and figures are useless, if not dangerous, without a sound theory" (F. Galetto), "Management need to grow-up their knowledge because experience alone, without theory, teaches nothing what to do to make Quality"(Deming) because he had seen, like Deming, Gell-Mann and F. Galetto "The result is that hundreds of people are learning what is wrong. I make this statement on the basis of experience, seeing every day the devastating effects of incompetent teaching and faulty applications." [Deming (1986)]

During 2006 and 2020, F. Galetto experienced the incompetence of several people who were thinking that only the "Peer Review Process" is able to assure the scientificity of papers, and that only papers published in some magazines "good" are scientific: one is a scientist and gets funds if he publishes on those magazines! Using the scientific method one can prove that the referee analysis does not assure quality of publications in the magazines. You can see the incompetence level in Research Gate, in Academia.edu, iSixSigma and Minitab19 (wrong formulae for T_Charts)...

The symbol ϵQ_{GE}^{IO} [which stands for the "epsilon Quality"] was devised by the author to show

that Quality depends, at any instant, in any place, at any rate of improvement, on the Intellectual hOnesty of people who always use experiments and think well on the experiments before actually making them (GedankenExperimenten) to find the truth" [GedankenExperimenten was a statement used by Einstein; but, if you look at Galileo life, you can see that also the Italian scientist was used to "mental experiments", the most important tool for Science; Epsilon (ϵ) is a Greek letter used in Mathematics and Engineering to indicate a very small quantity (actually going to zero); "epsilon Quality" conveys the idea that Quality is made of many and many prevention and improvement actions].

Many times the author spoiled his time and enthusiasm at conferences, in University and in Company courses, trying to provide good ideas on Quality and showing many cases of wrong applications of stupid methods [see references]. He will try to do it again ... by showing, step by step, one case (out of the hundreds he could document)... in order people understand that Quality is a serious matter. The Nobel price R. Feynman (1965) said that "for the progress of Science are necessary experimental capability, honesty in providing the results and the intelligence of interpreting them... We need to take into account of the experiments even though the results are different from our expectations." It is apparent that Deming, Feynman, and Gell-Mann are in agreement with ϵQ_{GE}^{IO} ideas of the

author. Once upon a time, A. Einstein said "Surely there are two things infinite in the world: the Universe and the Stupidity of people. But I have some doubt that Universe is infinite". Let us hope that Einstein was wrong, this

time. Anyway, before him, Galileo Galilei had said [in the Saggiatore] something similar "*Infinite is the mob of fools*".

All the methods, devised by the author, were invented and have been used for preventing and solving real problems in the Companies he was working for, as Quality Manager and as Quality Consultant: several million € have been saved.

Companies will not be able to survive the global market if they cannot provide integrally their customer the Quality they have paid for. So it is of paramount importance to know correctly what Quality means. Quality is a serious and difficult business; it has to become an integral part of management.

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The Birrarung Act: Between a Decolonial Nation-State and Settler-Colonialism

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Abstract- The Yarra River Protection (Wilip-gin Birrarung murrn) Act 2017 (Vic) established a 'new and independent' body as the 'voice of the river'. The Victorian state government considers it to be at the legislative forefront in the emancipation of First Nations Australians. Whilst attempting to replicate some of the languages behind other political settlements agreed between settler-colonial states and First Peoples over rivers and their guardianship, the Victorian Act grants no legal personhood to the Birrarung. It does not establish First Nation Australians as the legal guardian of the river, either. Instead, the Act sets up a statutory advisory body which mandates at least two Indigenous Traditional Owner representatives out of twelve appointees (representing other stakeholders), as made by the Minister for Planning (Yarra River Protection (Wilip-gin Birrarung murrn) Act). Despite the limited representation of Indigenous Peoples in the advisory body, the legislation does contain substantive provisions, indicative of a minor 'decolonial moment' in the face of sustained 'coloniality' by the nation-state. A philosophical analytical framework of 'coloniality' is applied to the legislation to undrape exactly where the cutting edge of First Nations' emancipatory legislation actually is.

Keywords: *birrarung, yarra river protection act, decoloniality, legislative analysis, settler-colonialism.*

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The Birrarung Act: Between a Decolonial Nation-State and Settler-Colonialism

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I. INTRODUCTION

The Yarra River Ministerial Advisory Committee was formulated in January 2016 to delve into issues impacting the environmental, cultural, social and economic values of the Yarra river (hereinafter the 'Birrarung') (Yarra River Protection Ministerial Advisory Committee et al., 2016, p.4). Between January to March 2016 a number of workshops were held with key stakeholders to help frame what would become the 'Protecting the Yarra River (Birrarung): Discussion Paper Summary' (hereinafter 'Discussion Paper') (Yarra River Protection Ministerial Advisory Committee and Department of Environment Land, Water and Planning, 2016; as per: Yarra River Protection Ministerial Advisory Committee et al., 2016, p.4) Despite seeking the input of other key stakeholders earlier on in the process, the input of the of the Wurundjeri Land Tribe and Compensation and Cultural Heritage Council (hereinafter 'Wurundjeri Council') was not sought until after the release of the Discussion Paper, in July of 2016

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(Yarra River Protection Ministerial Advisory Committee et al., 2016, p.3). In September 2016 the 'Protecting the Yarra River (Birrarung): Ministerial Advisory Committee Final Report' (hereinafter the 'MAC Final Report') was released by the Ministerial Advisory Committee, making a number of recommendations to the Victorian Government (Yarra River Protection Ministerial Advisory Committee et al., 2016, p.4). In 2017, the Yarra River Action Plan (Wilip-gin Birrarung murrn) (hereinafter 'Action Plan') was released as the Victorian Governments' response to the MAC Final Report, and this accepted 28 of the recommendations in full, partially accepting the remaining two recommendations (Department of the Environment, Land, Water and Planning, 2017b, p.6). Of these 30 recommendations, recommendation five was the preparation of a legislative bill to establish an "overarching planning framework" for the Birrarung, coordinating waterway, public land and infrastructure management, as well as cultural, heritage, and statutory land use planning (Department of the Environment, Land, Water and Planning, 2017b, p.13). It would have a "clear role" for amenity planning (Department of the Environment, Land, Water and Planning, 2017b, p.13).

On the 26th of September 2017, the Yarra River Protection Act (hereinafter 'Birrarung Act') received Royal Assent (Yarra River Protection Ministerial Advisory Committee et al., 2016; Yarra River Protection Ministerial Advisory Committee and Department of Environment Land, Water and Planning, 2016). This is the first piece of Victorian legislation to explicitly include a land-use planning framework in a water planning document (as administered by the Minister for Planning)(Department of the Environment, Land, Water and Planning, 2017b). The Birrarung Act mandates the creation of the Yarra Strategic Plan (hereinafter 'Strategic Plan') as the legislative instrument designed to implement the Birrarung Act. The draft version of the Strategic Plan has recently been released for public comment; although of use as a looking glass into the execution of the Birrarung Act, the Birrarung Act is the primary object of study, not its legislative instruments.

Upon this Act the analytic light of coloniality shines,ⁱ projecting shadows against the wall. From these silhouettes the developmental agenda reserved specifically for First Nations peoples of the Australian settler-colonial society can be exposed. In this way, the apparatuses of the nation-state can be seen in action,

through an Act of the settler-colonial parliament, whilst the legislation is spruiked as decolonial. This paper recognises that despite the decolonial logics adopted in the presentation of the Birrarung Act, the reality is it explicitly avoids challenging the existence of the nation-state – in this way it reinforces the legitimacy of the existence of the settler-colonial state (Sium, 2012). While it cannot be considered a truly decolonial moment, its creation reflects a growing trend of collaborative engagement between First Peoples and the settler-colonial nation-state when compared to prior water management regimes of the Birrarung.

Based on the case of the Birrarung Act, it is argued that the reformed governance structures of the Birrarung have adopted some decoloniality logics through the inclusion of the Birrarung Council (with its mandated inclusion of two indigenous members). The attempt at management of the river as a 'living entity', the recognition of past wrongs committed against First Nations Australians (and attempts to remedy these) reflect this. Similarly controls aimed at maintaining the biodiversity, and protecting inter-cultural values along the river are also understood to be some of these decoloniality logics. Finally, the limited public participation and engagement mechanisms, and the attempt at 'border' epistemologies bookend the analysis of the limited efforts towards decoloniality.ⁱⁱ It is apparent however, that there are far more examples of the coloniality hegemon being reinforced through this legislation. A number of further reforms could have furthered decoloniality without delegitimising the legal basis of an entire settler-colonial society.

Analysis will be grouped around the objects and principles of the Birrarung Act (2017) and elements within the Act constituted from the MAC Final Report (2016), the Action Plan (2017), and the Strategic Plan (2020). The research paper itself will start by addressing the context of the Birrarung's governance: its history in settlement and coloniality. The paper will then advance beyond, into how this legislation challenges the colonial ways of managing lands, peoples, and waters in Australia. This section will also delve into how these approaches are reflective of the broader 'development' processes in Australia. The final section will be addressing the failures of the Act to highlight some of the precepts of decoloniality as advanced by leading academics in the field.

This paper's primary interest lies in its application of an epistemic lens of analysis to the newly created legislation of a settler-colonial state. In adopting a law and development lens to deconstruct legislative technology in a Global North nation-state, it is possible to compare the treatment of Indigenous Australians, with Indigenous Peoples of Global South nations. The resonance between these two groups, and how they're 'developed' connects to Australia's continued settler-colonial modernist agenda. Viewed through this lens,

the continued mobilization of legislative technology affirms that domestic legislation continues to colonize, and yet parts of the legislation actually meet the standards argued for in the premise of decoloniality. In this respect, the legislative technology is a double-edged sword.

To analyse the case study, the framework of coloniality and decoloniality as it is conceived by Anibal Quijano and Walter D. Mignolo in their respective chapters in the theoretical work 'Globalization and the Decolonial Option' (2013) will be used (Quijano, 2013; Mignolo, 2013). Their research is globally recognized for its radical undraping of logics behind Western Imperialisms, and has led to the conceptualisation of the coloniality of power matrix (Hoffman, 2017). To understand the arguments of the colonial matrix of power, it must be recognised that modern nation-states as they exist today are ordered according to the historic distribution of power that colonisation and empire crafted (Pahuja, 2005). This modernist paradigm has come to ensconce the law and development field (Pahuja, 2005), because empire so focused upon the subjugation of civilizations it conquered. James Baldwin debated William F. Buckley in 1965, and argued that the Western system of reality (as he termed it) had sought to subsume within it civilisations' it considered below itself (Debate Transcript: James Baldwin Debates William F. Buckley, 1965). He went onto to state the most private affect this violence has on the individual, was to destroy their own sense of reality (Debate Transcript: James Baldwin Debates William F. Buckley, 1965, p.1). Baldwin's critique is critical in understanding how the construction of reality, or epistemology plays an intrinsic role in the creation of knowledge systems. The all-encompassing nature of what is termed 'empiricism', and the historical realities of where this method of knowing the world comes from, are reason enough to query traditional tools of analysis that are founded in these methods. This is especially so, when observing ostensibly decolonial legislation, under the microscope.

Mignolo, and Quijano argue that empire was key to the advances of Euro-America during the age of enlightenment and the renaissance period, giving birth to the scientific method of enquiry (Mignolo, 2013; Quijano, 2000). The scientific method of enquiry is introduced here, because conceptualising this method, as a child of the empire-colonial-modernism reveals that it cannot be unbiased in its interpretation of phenomenon (Quijano, 2013; Mignolo, 2013, 2011; Quijano, 2000; Mohr, 2019; Harding, 1997). These biases ensures that not only are sciences to distorted along ideological beliefs, but that to this day the application of scientific truths that fundamentally constitute reality are warped (Quijano, 2000). At worst, they are inaccurate and untrue. Therefore modernism, and the history that lead to the construction of that epistemology cannot be trusted to be without prejudice

(Armstrong, 2002; Quijano, 2000). This extends to anthropological sciences, which have influenced successive law and development paradigms. For reasons of internalised bias, the attempts at decolonising guided by anthropology remain epistemically at odds with indigenous ontology. Whilst each new law and development paradigm has attempted to reshape the legal systems of former colonial subjects, the underlying conflicts between modernist epistemology, and indigenous ontologies ensures these reforms remains captive to modernist/post-modernist epistemology, and the agenda of 'development' (Escobar, 2007). Quijano argues that empirical sciences are trapped within the epistemology of universalities and the 'ultimate scientific truth' (Quijano, 2013). This preconceived notion of abstract universals and scientific truth, is part of the 'colonial matrix of power',ⁱⁱⁱ as described by Quijano and Mignolo (Quijano, 2000). These are deconstructed as empirical vestiges of coloniality, rather than being true representations of knowledge. To remedy these incongruencies, Quijano and Mignolo advocate building inter-cultural understandings between modernity and indigenous ontology (Mignolo, 2013, p.500). The law and development agenda continues to maintain a steadfast belief in this universal truth, and struggles to balance this against indigenous epistemology (Mignolo, 2013). Mignolo states that decoloniality arose from the limits of of the universality of coloniality.

Additionally, elimination and assimilation are adopted as tools of enquiry into the nature of this legislation. Patrick Wolfe adopts the terms elimination, and assimilation, of indigenous identity (hereinafter 'indigeneity') as lenses of analysis in their critical article 'Settler colonialism and the elimination of the native'. Wolfe argues that colonisation is a structure of a society, rather than a historic event. From this vantage, Wolfe suggests that the elimination of indigeneity (through assimilation into the dominant settler-colonial social order, or elimination through genocide) is a common feature of these settler-colonial societies (Wolfe, 2006). Paul Havemann in 'Denial, Modernity, and Exclusion: Indigenous Placelessness in Australia' further argues that colonisation has been the key feature of modernity and, it's imperative has been to conquer space for economic growth and state order building (Havemann, 2005). Havemann goes on to argue that First Peoples have been consistently excluded from modernisation processes in Australia, and that the violence in exclusion from modernisation, has been masked specifically through the use of legislative technologies (Havemann, 2005). So it is argued that law has been complicit in hiding not only the atrocities of colonisation, but also denying the advances which modernisation brings, to First Peoples (Havemann, 2005).

The above described analytics will be utilised to understand where modernisation and its mobilisation of

the concept of 'development' originated. These concepts will be used to examine the Birrarung Act and some parts of the legislative and policy regimes. In making this analysis the paper will argue from a decolonial perspective that this 'moment' of decolonisation within a colonial society is exactly that – a moment. It is a critique of this instant.

II. FROM INDIGENOUS TO SETTLER-COLONIAL PARADIGMS GOVERNING THE BIRRARUNG

The Birrarung (name translated as 'river of mists and shadows') has always been of central importance to the Wurundjeri-Willam people of the Kulin Nations who reside in close proximity to it (Wurundjeri Tribe Land and Compensation Cultural Heritage Council, 2013). It has provided innumerable resources to these peoples since time immemorial, and their relationship with it extends back tens of thousands of years to when their spirit-creator Bunjil formed their people, the land, and all living things (Koori Trust, 2019; Wurundjeri Tribe Land and Compensation Cultural Heritage Council, 2013). For First Peoples, it provided food as well as shelter. Bluestone, carved out by the riverbanks, was heated and then rapidly cooled to create sharp chisels. From these chisels, the blue gums along the Birrarung could be carved into, and this provided a sustainable source of materials for shields and canoes (Koori Trust, 2019). The trees would continue to grow afterwards, being unaffected by this process (Koori Trust, 2019). Lerp scale (collected from Eucalypt leaves) was consumed as breakfast, and Possum skins would be harvested and woven into elaborate cloaks detailed with the events of individuals lives' (Koori Trust, 2019). Eel traps set in the Birrarung still stand today as a testament to the agricultural traditions of these sophisticated nations (Koori Trust, 2019). All of these economic activities were entirely dependent upon the Birrarung and were strictly governed by local custom and law.

Prior to European interventions into the Birrarung, there was a waterfall close to the present day location of the Melbourne Aquarium (Koori Trust, 2019). This divided the saltwater from the freshwater, and prevented larger ships from travelling further up the Birrarung (Koori Trust, 2019). As Melbourne had yet to be proclaimed, much of the environment remained in pristine condition; large marshes lay across what is now Southbank (Wurundjeri Tribe Land and Compensation Cultural Heritage Council, 2013). Along the length of Elizabeth street was a large creek which empties into the Birrarung (Koori Trust, 2019). These wet and productive marshes offered a near constant supply of food to the Kulin Nations, and furthered the importance of the Birrarung to the traditional owners.

In these pre-colonial times, there was a strict adherence to local custom, and clan- based rules and laws (Wurundjeri Tribe Land and Compensation Cultural

Heritage Council, 2013). The legal systems of the First People was (and continues to be), underpinned by vastly different conceptions of country; rather than 'owning' the land, instead they belonged to the land (Wurundjeri Tribe Land and Compensation Cultural Heritage Council, 2013). In this sense, the Birrarung was centrally important as it acted as a wayfinding point, as well as a marker, delineating different nation's land title (Koori Trust, 2019). In those times, each clan was expected to remain within the bounds of their title, and not to cross into adjacent nations' land (Wurundjeri Tribe Land and Compensation Cultural Heritage Council, 2013). Exception was made in the cases of large natural disaster; but even in such an instance agreement needed to be sought (and permission granted) before moving into the land of another tribe (Koori Trust, 2019). Consent to move onto the land of another group was signified by Tanderrum, a message stick given by one tribe to another in those times of natural disaster; without this message stick, taking food or other resources from the land would be considered trespass and an offence to the local elder council (Koori Trust, 2019). If conflict arose between nations or language clans, or if there were individuals who had broken Aboriginal law, the ngurungaeta (head man) of tribes would meet at corroboree's to resolve these disputes (Wurundjeri Tribe Land and Compensation Cultural Heritage Council, 2013). Even now, the traditional legal systems and customs of these peoples continue to be practiced and respected by the First Peoples who call this land their own. What is most apparent from these histories of the Birrarung is that it has consistently been important to First Peoples.

Since the beginnings of colonisation in Melbourne in the 1820s, the Birrarung has undergone three periods of extended change in form: first during the Gold Rush years of the late 1800's; the post-war immigration and baby boom of the 1950's-1980's; and now, the recent and rapid expansion of Melbourne's population since the mid 2000's.

The most important of these settler-colonial governance tools over the Birrarung have been the 1989 Victorian Water Act, and the 2017 Birrarung Act. The Water Act is the current governing legislation for water in the Birrarung. This set up the numerous water management corporations which are now responsible for the management of water resources along the Birrarung (The Water Act). The National Water Initiative introduced as an intergovernmental agreement between the Commonwealth and the states/territories began the process of 'unbundling' water licenses, from land ownership, and opening up 'water markets'; inevitably this has led to further dispossession of First Peoples from water rights (Macpherson, 2017; Marshall and Kirby, 2017; Macpherson, 2019). Repetition of this has led to the term *aqua nullius* being coined by Virginia Marshall, to describe the continued disenfranchisement

of First Peoples from their sovereign assets (to be discussed further in proceeding sections). It is argued the water markets have been another settler-colonial institution separating First Peoples and their waters (Marshall and Kirby, 2017; O'Bryan, 2017). In 2007 the National Parks Act (passed in 1975) was amended to turn over the governance of the Yarra Parklands (the source of waters which drain into the Birrarung basin), retaining it as crown land (The National Park Act). This land is titled as a possession of the crown, and its representatives (the state) in this instance.

In 2017 the Birrarung Act received royal assent. Stemming from the MAC Final Report, and the Action Plan, the Birrarung Act mandates the creation of a community vision; a strategic plan from this vision to manage the river and lands adjacent to it (the Strategic Plan); new management arrangements to make certain this plan is implemented (the Birrarung Council); legislative backing of the plan (the Birrarung Act itself); and auditing/reporting on the implementation of the plan (as achieved by the Birrarung Council).^{iv} The Birrarung Council, is a statutory advisory body formed with a mandated two First Nations Australians on the council of twelve, and reports on the implementation of the plan as well as general submissions for change to the Minister for Planning (Yarra River Protection (Wilip-gin Birrarung murrong) Act). Most importantly though, the Birrarung Act is an example of mediating between competing interests by considering water planning and land-use frameworks together. This is the first piece of Victorian legislation to expressly consider the water resources and land management together, under the planning scheme. The Strategic Plan explicitly includes a land-use framework in a water planning document (Department of the Environment, Land, Water and Planning, 2017b, p.27).

Taken together, these changes essentially coordinate and organise the roles of ten different bodies (operating independently of each other and with limited interface) to proactively work together on managing and maintaining the river (Yarra River Protection Ministerial Advisory Committee and Department of Environment Land, Water and Planning, 2016).

III. ASSERTING THE ARGUMENT FOR A LAW AND DEVELOPMENT LENS OF ANALYSIS TO BE APPLIED TO THE WILIP-GIN BIRRARUNG MURRON ACT

Centralised planning is a consistent feature of 'development' initiatives and, more broadly, of coloniality. Speaking on the innate connections between law and development, coloniality, and modernity, Sundhya Pahuja argues that the transformative logics of development have acted as both a proxy for global inequalities and an implication that the only solution to such inequities is to mirror the West (Pahuja, 2005). They go on to argue that the promotion of the 'rule of

law' as a gateway to development reveals just how Western the conceptions of political theory and jurisprudence are (Pahuja, 2005). Again a universality is apparent in these logics, negating the pluri-versalities so advocated through coloniality/decoloniality. Urban planners have themselves have advocated for the need to 'decolonise planning' (Porter, 2016; Porter and Barry, 2016; Jackson, Porter and Johnson, 2017; Wensing and Porter, 2016). It has been suggested by many that academic urban planning needs to not only better integrate and engage First Australians, but to also decolonise its institutions and recognise its role as an agent of colonisation (Wensing and Porter, 2016). Planning has worked alongside centralising authorities to project ideologies of modernity onto the natural and built form; it is indivisibly tied to the continued domination of First Australians. For that reason, the centralization of power (and its associated planning for control) is not surprising in development initiatives. Intentionally done or not, these initiatives further such power dynamics.

This thesis is more thoroughly explored through the work of Peter Wolfe who propounds the following three tenets: 1. "[Coloniality] presupposed a global chain of command linking remote colonial frontiers to the metropolis" (Wolfe, 2006, p.394), therefore 2. "Agriculture was key to supporting a larger population than non-sedentary modes of production; in settler-colonial terms" and "this enable[d] a population to be expanded by continuing immigration at the expense of native titles and livelihoods" (Wolfe, 2006, p.395). These were enforced by the centralized command chain, which led to "3. the settler-colonial nations' "ceaseless expansion" and, '[its'] agriculture progressively eat[ing] into indigenous territory' (Wolfe, 2006, p.395). The accumulation of agricultural resources turned "native flora and fauna into a dwindling resource" and "curtail[ed] ... indigenous modes of production' (Wolfe, 2006, p.395). Partha Chatterjee terms this as development planning and argues that this approach was premised upon "one consciousness and will – that of the whole" and therefore particular interests needed to be "subsumed within the whole" and made "consistent" with the "general interest" of settler-colonial society writ-large (Chatterjee, 1995, p.204).

Undoubtedly the above described contours are similar enough to those in the Birrarung Act, in that it is a categoric reinforcement of the 'development' narrative in action. That this legislation is under the urban planning ministerial portfolio (not the Minister of Indigenous Affairs; not the Minister of State; not the Attorney-General; not the Minister of Water; nor the Minister of Agriculture) reinforces this. It speaks to Chatterjee's statement that all types of planning and development are intrinsically linked. It is also reflective of the importance of omnipotent control of the river by the settler-colonial state; the river plays an important role in

the functioning of the settler-colonial city. Despite the stated aim of protecting the river and celebrating indigenous values, the minister for planning has the discretion to 'call-in' any planning permit application under section 97 of the Planning and Environment Act 1987 (Vic) (hereinafter 'P&E Act'), and Section 58, Schedule 1 of the Victorian Civil and Administrative Tribunal Act 1998 (Vic) (hereinafter 'VCAT Act') (The Victorian Civil and Administrative Tribunal Act.; The Planning and Environment Act; Department of the Environment, Land, Water and Planning, 2017a). They may and approve or reject the project as they see fit without any regard to regular statutory process (The Victorian Civil and Administrative Tribunal Act.; The Planning and Environment Act). In addition, the decision to 'call-in' any planning application can be made if the matter is being heard by the Victorian Civil and Administrative Tribunal and if the minister considers that the proceeding raises a major issue of policy (The Victorian Civil and Administrative Tribunal Act., p.1). Alternatively, if the ministers considers proceedings may have a substantial effect on the achievement of planning objectives, they may also call-in the application for approval or rejection (Department of the Environment, Land, Water and Planning, 2017a, p.1). In the case of the Planning & Environment Act 1987 (Vic) (hereinafter 'P&E Act'), the minister can call in a decision if the same is considered above, or if the decision on the application has been 'unreasonably delayed', disadvantaging the applicant (Department of the Environment, Land, Water and Planning, 2017a, p.1). The minister may also call-in a decision under the P&E Act if the 'use or development' that the application seeks to be approved is required to be considered by the Minister – such as a planning permit for a heavy industrial use (Department of the Environment, Land, Water and Planning, 2017a, p.1).

This backdoor centralisation of power perhaps elucidates a common thread throughout this legislation – that indigenous concerns are important, but a legitimate escape clause is forever present. This opaque and unreserved power for development approval means in spite of all the planning permit regulations; protection of environment clauses; or protections from development, these protections can easily be overcome. In essence, these protections can be vetoed by the minister through approval of planning permit. Furthermore, the decisions of the minister are only able to be reviewed by a planning panel – appointed by the minister for planning. Such reports can only be released at the discretion of the minister (Department of the Environment, Land, Water and Planning, 2017a; The Planning and Environment Act; The Victorian Civil and Administrative Tribunal Act.). This has the effect of making decisions under made under the aforementioned provisions quite opaque (Department of the Environment, Land, Water and Planning, 2017a, p.1). The Victorian planning minister has comparatively more

discretionary powers, than fellow counterparts in the other jurisdictions of Australia (Environmental Justice Australia, 2014). This fact, coupled with the lack of transparency of decision-making has been roundly criticized in the past, and yet there is no indication of reform on the horizon. Although it is arguable that ministerial discretion is a feature of most legislation, this does not invalidate the fact that a backdoor 'escape' has been deliberately included within the Birrarung Act. Additionally, broader questions about the role of democracy in urban planning decisions, as it relates to First Peoples, need to be asked – as do questions about the Minister of Planning's discretionary powers (Department of the Environment, Land, Water and Planning, 2017a).

Finally, it must be noted that centralised powers have an outsize role in shaping the development narrative (Chatterjee, 1995). This reflects the modernist paradigm which now sees planning as a tool to be wielded over First Peoples. Wide latitudes under which to make decisions over the management of the Birrarung have been granted through the passage of this legislation. Such powers were previously unavailable to the Minister for Planning. Such a change reflects a growing trend of consolidation of executive power, and is of particularly note due to the outsize role centralised powers have had in setting the development agenda.

Most important to the justification for the novel approach of adopting a law and development lens of analysis in a Global North nation-state, is that the narrative of development being applied to those considered the 'other' becomes apparent. Havemann's arguments about the exclusion of First Nations Australians from modernisation processes and this being hidden by the law, qualify that First Australians' are indeed considered the 'other' (Havemann, 2005). By being ensconced within 'otherness', Indigenous Australians become the subjects to whom the logics of modernity, coloniality and development can be applied. Then it follows that the logics of modernity/coloniality/development are not restricted to Global South economies, but are designed for those not yet ingested in service of the nation-states expansive appetite for modernization and development.

IV. ORIENTING FROM A LAW AND DEVELOPMENT LENS, TO 'COLONIALITY/ DECOLONIALITY' AND 'ELIMINATION/ ASSIMILATION' AS A FRAMEWORK FOR ANALYSING THE WILIP-GIN BIRRARUNG MURRON ACT

'Coloniality, in other words, is constitutive of modernity — there is no modernity without coloniality' — Walter D. Mignolo (2011, p.1)

Walter D. Mignolo, and Aníbal Quijano in the book 'Globalization and the Decolonial Option' define coloniality as beginning with the formation of the modern nation-state. It is suggested that the 'modern' nation-state that has emerged since the 1500's has come into being through colonisation; and that power is distributed according to a global order that has since ensued. The 'colonial matrix of power' is defined by Quijano as the four interrelated domains by which colonisers subjugated indigenous lands. These include the control of economy (land appropriation, exploitation of labor, control of natural resources); the control of authority (institution, army); the control of gender and sexuality (family, education); and the control of subjectivity and knowledge (epistemology, education and formation of subjectivity) (Quijano, 2013). It is through these domains, that the modern nation-state and its logics continue to assert universalism in our global modernist/post-modernist paradigm.

Most important to Quijano and Mignolo's analysis is the privileging of the 'ultimate truth' and how this is articulated through the 'rational' scientific method (itself a product of the enlightenment period). This was when the first 'modern' precepts of rigorous empirical testing, hypothesizing, and validating of data to explain phenomenon was conducted (Mignolo, 2013). These processes coincide with the beginnings of empire throughout Europe; first the Iberian Catholic faces of the Spanish and Portuguese empires; then the 'heart of Europe' empires in the form of England, France and Germany (This period was also characterized by the discovery and colonisation of the American mainland) and finally with US-American empire, led by the United States (Mignolo, 2011, 2013, 2017, p.454).

Karen Armstrong, in her book *Islam: A Short Story*, suggests that until the sixteenth century, Europe had only truly achieved in two spheres: economy and epistemology (Armstrong, 2002; Mignolo, 2011). The economic sphere spoke specifically to the transition from a feudalist society to a capitalist one (although this transformation had not been completed by this point), and the epistemic refers to its understanding of art, science, and knowledge (Armstrong, 2002). Armstrong makes reference to the new and evolving economics of the societies of Europe (and its American colonies) during this period (Armstrong, 2002). This new economics sought to reinvest surplus production into itself, which allowed for the first radical transformation in the West (Armstrong, 2002). This transformation allowed the West to reproduce its resources indefinitely (many of these resources being abstracted from imperial colonies (Armstrong, 2002). The second transformation was epistemological, and is largely associated with the Renaissance (and then the Enlightenment) (Armstrong, 2002; Mignolo, 2011). Naturally the surpluses generated from these new economies that would come to fund the Renaissance and the Enlightenment (and the

burgeoning scientific method of enquiry) were extracted from the wealth of the colonies (Armstrong, 2002; as per: Mignolo, 2011). Additionally, this transformation allowed the domain of knowledge to be attained at unprecedented rates; it gave the empires a greater control over the environment than had ever been achieved before (Mignolo, 2011). Suddenly, a new paradigm was possible for these empires, and a lens through which the world came to be was born. This then led to Euro-American belief in how the rest of world would, and should develop. It could be created within the fixed image of these modernist states (Mignolo, 2013).

Arguments about coloniality assert the existence of a 'universality' in human 'development', inextricably tied to the modern nation-state. 'Developing' nations are conceived to be on the same trajectory of western nation-states, merely less 'developed'. In this view the West conceives of itself as the future for the rest of humanity, and so implements 'development' policies accordingly (Mignolo, 2011, p.458). It follows then, that decoloniality is constituted by a rejection of universality, and instead is founded on a 'pluri-versality' of epistemologies and ontologies constructing a knowledge of the world.^{vi}

It is important to recognise the nature of colonisation within Australia and how it has come to define the legal and social order. Mary Williams argues that Australia has 'never desisted in colonialism' and that colonialism will 'draw upon (and twist where necessary)' other discourses to 'facilitate its ends of continually dispossessing and delegitimising' First Nation Peoples (Williams, 2018, p.1). Wolfe builds upon such thinking by arguing that because of the settler-colonisers intent to stay (and dispossess), the invasion was transformed into the undergirding for the present-day social structure (Wolfe, 2006). This is reflective of post-colonial societies that have emerged the world over; they are a social order that has been mobilised throughout history, premised on the elimination of indigeneity (Wolfe, 2006, p.390). Elimination of indigeneity did not preclude genocide entirely, but focused instead on the destruction of permanent indigeneity (Wolfe, 2006); whilst the mass murder of Indigenous Peoples was common, elimination was not predicated on mass murder (Wolfe, 2006, p.390). Genocide was one 'tool', of a number of tools to be used in the process of eliminating indigeneity (Wolfe, 2006, p.396). Assimilation into the 'modern' and coloniality-driven society was just as acceptable an approach, so long as it was predicated on the dispensation of indigeneity. (Wolfe, 2006, p.397).

Assimilation and extinguishment of indigeneity continue to define these settler-colonial societies; the judiciary keenly reinforce these in their rulings, which void claims of indigenous land tenure systems (under the common law) due to the 'tide of history' having

'washed away' all remnants of these societies.^{vii} Despite having common law doctrines to rely upon in statutory interpretation, the High Court of Australia has often favored the sovereignty of Parliament (Blackshield, 2007). Therefore, it is from this frame of racialization and assimilation of Indigenous Australians (coinciding with the 'closure' of the 'frontier' of settler-colonial societies) that analysis of coloniality will be informed. This decisive point also happens to be when active warfare against indigenous peoples was transmuted to subversive and destructive policies and laws, further highlighting why such tools of analysis are of importance in understanding coloniality.

As such, questions over euro-centric representation of histories must be asked to understand the degree to which aboriginal-ism has been intrinsic to the formation of the Victorian state legal system of present. Transposing the assertions made in Mignolo, Quijano, and Wolfe's works will form the basis of the tools of analysis in proceeding chapters.

The terms 'Intercultural border epistemologies/intercultural understandings' refers to the construction of knowledge where two different cultures interface. In this instance, the tools of analysis are querying if 'intercultural' understandings of politics, economics and ethics are present in the Act (Mignolo, 2011, p.453)? This draws into the broader concerns of coloniality/decoloniality, and whether one single vision of the future (a 'totality'), of the modern Australian nation-state (specifically the state of Victoria) are being implied. To operationalise the assertions made by Mignolo and Quijano through coloniality/decoloniality to be a lens of analysis, they were transposed into questions. This resulted in the following lines of thematic enquiry being developed:

- Are there links made between the analysis of coloniality and future strategies present in the Birrarung Act (and its instruments'), which are conveyed with a self-awareness of the continuity of coloniality?
- Are 'reason' or 'rationality' and 'nature' presented as two mutually exclusive entities (Mignolo, 2013, p.172);
- Are there are clear examples of how many traditional theories of knowledge (as drawn from indigenous cultures) and 'modern processes' are bought together inside the Act;^{viii}
- Within the Act, does the 'rhetoric' of modernity appear (Mignolo, 2011, p.462);
- Does the Birrarung Act offer some kind of critique of the 'colonial matrix of power' (Mignolo, 2011);
- And finally, are specific epistemologies being privileged above others (Quijano, 2013)?

By probing these, it should be obvious that the Birrarung Act is more than a vain attempt for the coloniser to decolonise themselves. It should also be

apparent that one form of social development (a 'totality' of society at large) isn't being suggested (Quijano, 2000, p.173). This should all indicate that it is possible for free production, criticism, changes and exchanges of culture and society to occur, as Mignolo and Quijano so vigorously advocate for (Mignolo, 2011, p.497). These assertions are relevant because Australia is a settler-colonial state similar to those from which Mignolo, Quijano, and Wolfe write. As this context is legitimately comparable to Australia, the tools proposed to analyse are able to uncover structures of power behind the regulation of the Birrarung.

The primary focus of analysis is concerned with the intercultural understandings of politics, economics and ethics, as Mignolo argued that these are constituent of a singular common totality of the modern nation-state. Looking specifically at the 'Objects' of the Act, the 'Guiding Principles' will first be analysed; and then examination will move on to the 'Recommendations' made in the MAC Final Report. Strategies outlined within both the Birrarung Act and the MAC Final Report are analysed in relation to the above described thematic questions.

In asking these questions of coloniality and decoloniality, it is possible to critically analyse the languages of the legislation, its delegated instruments, and the foundational advisory materials for governance reform. These questions are of particular significance because of the urban nature of this river; Mignolo observes that 'coloniality of power' is strongly associated with the emergence of urban, capitalist social relations (Quijano, 2000, p.175). This Act is therefore constitutive not just of a decolonial moment in the settler-coloniality nation-state, but in the structure of coloniality because it intersects with urban, capitalist and social relations. Through this analysis of intercultural understandings, along with conceptions of coloniality and looking to see if traditional and modern theories of knowledge have been brought together in the Act, insights can be gained into what structures of decoloniality are at work in a modern coloniality-driven nation-state – and how they may be mobilized through legislation.

V. DECONSTRUCTING THE BIRRARUNG ACT 2017 (VIC): CHALLENGING 'COLONIALITY' AND 'DEVELOPMENT'

'SO far as Indigenous People are concerned, where they are IS who they are, and not only by their own reckoning' – Patrick Wolfe (2006, p.388)

In Part 2 of the Birrarung Act, the 'Yarra Protection principles' are set out. These entail subsections entitled 'General Principles', 'Environmental Principles', 'Social Principles', 'Recreational Principles', 'Cultural Principles', and 'Management Principles'. For the purposes of our analysis, focus is directed towards

the 'General Principles', 'Environmental Principles' and 'Social Principles'. Of the General Principles, the first general principle states that

(1) Proposed development and decision-making should be based on the effective integration of environmental, social and cultural considerations in order to improve public health and wellbeing and environmental benefit' (Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.11).

The implicit statement in this guideline is that 'cultural' considerations (referring to Indigenous Australians 'dreaming'; but also, the values of diverse non-Indigenous cultures and heritage) is valued equally with environmental and social considerations. Although further within the Birrarung Act there is reference to cultural diversity and heritage (including post-European colonisation buildings), there is an evident desire to build intercultural knowledges and understanding. Arguably, including both pre- and post-colonial heritage and cultural diversity is itself an example of seeking to combine settler-colonial, and indigenous values as one and equal.

In Principle (4) it is stated that:

(4) 'Each generation should ensure that the environmental, social and cultural benefits that have been acquired are maintained or enhanced for the benefit of future generations (Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.11).

In this statement, longevity and intergenerational nature of intercultural understandings and values is referenced. While the adoption of 'should' suggests that these 'benefits' cannot be codified and protected under the Act, it also places the onus of responsibility of maintaining these 'benefits' on a future generation. By lengthening timescales out, this aligns with institutional expectations that these can, and will be, a part of the future of the Birrarung (and its' peoples). The links that are made, reflect an epistemic shift (even if tenuous) in the politics of how the Birrarung is perceived. The changing polity reflects a new notion of what is important to people, and what should therefore be protected under law.

In Social Principle (1), it is stated that

(2) 'The existing amenity of Yarra River land, including its natural features, character and appearance, should be protected and enhanced for the benefit of the whole community' (Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.12).

Amenity is described as the 'features' of the parkland that 'engage community connection with nature, culture, heritage' in addition to 'enhanc[ing] community health'.^{ix} There are elements of the modernist conception of humans as above the natural world (implicit in the demarcation of 'human' and 'nature' as separate entities). However, the definition of 'amenity' to include different values reflects the rejection of traditional notions of the value of 'nature' (Kanth,

2017). This is because of Euro-American modernisms' fundamental belief in the hierarchy of human above nature, and therefore the culture and heritage (of humans) are valued more.^x It also reflects a partial deconstruction of 'nature' in that previously 'nature' had been perceived as being completely separate from the functioning of modern society; now the intrinsic values and health benefits that 'nature' provides to the wider community, are recognised in law. Although this recognition continues the modernist trend of commodifying nature to achieve anthropogenic wants and needs, the fact remains that nature is recognised to be of intrinsic value to humans.^{xi} The inclusion of health is important because already there is a copious amount of evidence linking human interaction with nature to improved health outcomes for humans.^{xii} The health benefits of public open space and 'natural' environments are clearly one of the features being sought after through the inclusion of urban parklands along the Birrarung.

The languages adopted in the first and second Environmental Principles demonstrates the dualism of ideologies at play within the Act. Both allude to the precautionary principle, a well-known (albeit, poorly defined) concept in international environmental law (one which is also defined in domestic legislation) (Freestone and Hey, 1996, p.4; O'Riordan, 2013; Trouwborst, 2007).

The Birrarung Act states:

1. 'If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation or for failing to assess the risk-weighted consequences of the options'(Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.11);
2. 'Environmental practices and procedures should ensure that biodiversity and ecological integrity is maintained or enhanced in ways that are proportionate to the significance of the environmental risks and consequences being addressed (Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.12).

The rhetoric presents a dichotomous trans-modernity, a merging of indigenous and modernist epistemologies. Both principles rely on the mobilisation of the modernist scientific method (a product of coloniality), to 'protect' the cultural assets of Indigenous Peoples (a moment of decoloniality). The Birrarung Act states that if there are 'serious threats' of irreversible environmental damage to the river, then a 'lack of scientific certainty' in assessing this risk, is an invalid excuse for proceeding. Here it appears the precepts of modernity (and its reliance on empiricism) have been pressed into service for the defense of Indigenous assets. That the Indigenous values of this river should

have consequence and in-built protection mechanisms for these specified within the legislation, reflects a growing awareness of these cultural values. It is difficult to justify this as decolonial in the nature that Quijano or Mignolo might conceive, not least because it is technically assimilating indigenous values it into the Australian legal system. Nevertheless, it reflects a desire to build an intercultural discourse which recognises, and protects part of the broader Indigenous Estate. Furthermore, this is revolutionary within Australia because it is one of the few instances in which indigenous holdings, so intrinsically important to these peoples, have been recognised in statute in the middle of an Australian city (Department of the Environment, Land, Water and Planning, 2017c).

To fulfill its legislative requirements in section 17(3) of the Birrarung Act, the Strategic Plan 'must' include 'active community participation and co-design' (Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.17). To establish this community vision Melbourne Water began a process in 2017 which culminated in the randomised selection of 24 citizens (known as the 'Yarra Community Assembly'), to write a fifty-year vision (Imagine the Yarra, 2020, p.1). The Yarra Community Assembly disseminated information from traditional owners, in addition to information discerned from other community engagement session (Imagine the Yarra, 2020, p.1). The Yarra Community Assembly then created the fifty-year vision, which has since been endorsed by the Victorian Government and the Birrarung Council (Imagine the Yarra, 2020, p.1). According to the legislation, the community vision is set to be reviewed each decade. This process is reflective of a broader drive to the institutions of deliberative democracy, which stem from Western Liberal Democracy. They have currency as an effective approach to allow public engagement, and are conceivably a trans-modernity, because they bring together traditional knowledges and modernist processes of state. Importantly, this approach reflects the principles of 'co-design'. 'Co-design' community engagement is defined in the Victorian Auditor General's Report 'Public Participation in Government Decision-Making' (Greaves, 2017). It is described as 'sitting at the more intensive level of the public participation spectrum, between Collaborate and Empower' (as depicted in Figure 1) (Greaves, 2017, p.1).

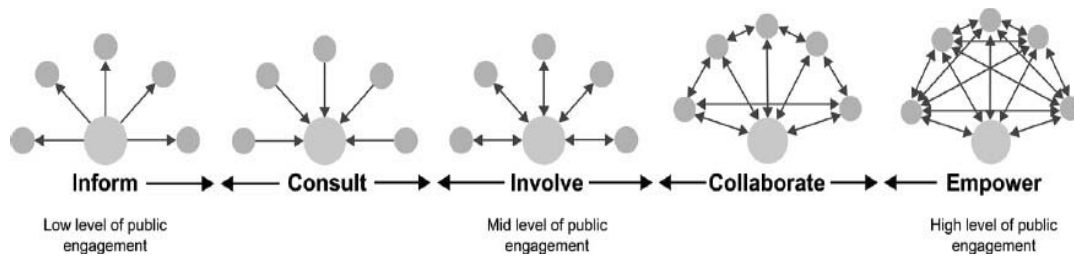


Figure 1: Victorian Auditor General's Office ('VAGO'), based on standard international practice from the International Association for Public Participation ('IAP2') Spectrum.^{xiii}

In this respect, the Birrarung Act performs well. Seeking the contributions of traditional owners into the institutions of deliberative democracy is an important step towards trans-modernity.

Major overhauls of the Victorian Environmental Protection Act 1970 (Vic) have passed, in concert with the Birrarung Act. Under the new Environmental Protection laws, community members directly affected by the breach of environmental protection laws will be able to seek remedy through a court (Department of Environment Land, Water and Planning, 2019, p.4). By extending the scope under which individuals who may take civil or criminal action if affected by breaches of environmental protection laws, there is further impetus for polluters to adopt the precautionary principle when interacting with the Indigenous Estate. This is a practical outlet through which a degree of power-sharing can occur, in that First Nations are now able to seek to enforce protection of their cultural assets through civil and criminal suits in court.

A similar agenda can be seen in the establishment of the Birrarung Council. Inclusion of First Nations members on the council allows for the expression of decolonial logics by First Nations. The intangible value that such voices are able to bring is recognized by their mandated appointment to the council. By making a space for these voices to be heard, intercultural epistemology building and border epistemologies understanding can occur. This reflects a broader change to societal values currently underway; prior to the Birrarung Act there was no mention of indigenous values, assets, or of the central importance of the Birrarung to First Peoples in major water management policy documentation.^{xiv} of similar import, was the foreword to the Action Plan, written by representatives of the Wurundjeri Council. They noted they were pleased to be 'sitting upstream, at the table where decisions are made' rather than their usual position downstream 'learning about processes that had occurred, and decisions made, 12 months' prior (Department of the Environment, Land, Water and Planning, 2017b, p.ⁱⁱⁱ).

Importantly, these new discussions have been enabled in the context of a wider push towards substantive engagement and inclusion of the Indigenous community in government processes.

Current practice within specific departments of the Victorian government is to support self-determination and to co-design, and co-create policy with Traditional Owners and other Indigenous communities as evidenced in numerous policy document. (Aboriginal Victoria, 2019a, p.1, b, p.1; Department of the Environment, Land, Water and Planning, 2019b, p.1, a, p.1; Local Government Victoria, 2016) This should be recognised as a significant intermediary step forward.

In spite of these decolonial modalities, the clear direction of the Birrarung Act and its delegated authorities is to reinforce coloniality and subsume elements of indigeneity into the common law, rather than. For one, the Birrarung Council is restricted to advisory status on implementation of the Strategic Plan, and general recommendations on the Strategic Plan. These are but the tip of the iceberg, and issues which fundamentally conflict with the precepts of decoloniality shall be explored further in proceeding sections.

VI. DECONSTRUCTING THE BIRRARUNG ACT: REINFORCING THE 'MODERNIZATION', 'DEVELOPMENT', AND 'COLONIALITY MATRIX'

Stated in the Birrarung Act, the objects of the Act are:

1. To recognise the importance of the Birrarung, and its parklands and associated public places, to the economic prosperity, vitality and liveability of Melbourne and the Yarra Valley, including—
 - a) The ecological health, and the cultural, social, environmental and amenity values of the Yarra River and the landscape in which the Yarra River is situated; and
 - b) The environmental significance of the biodiversity corridor along the Yarra River.

In addition to objects:

2. 'Recognis[ing] that Crown land and freehold land owned by the State, that is adjacent to the Yarra River and which is used as public open space or as a park, is part of the one living and integrated natural entity, and protect[ing] that land; and'
3. 'Establish[ing] an overarching policy and planning framework to coordinate; and harmonise planning

- for the use, development and protection of the Yarra River, its parklands and other land in its vicinity; and'
4. 'Establish[ing] the Birrarung Council to advocate for protection and preservation of the Yarra River (Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.10).

In assessing the Objects (A) subsections (i) and (ii) of the Act, a genuine push to re-envision the role the Birrarung appears in the desire to sustain the biodiversity and indigenous 'cultural expression' (through cultural activities) along the Birrarung. xv In spite of these aspirations, the languages of coloniality are already adopted in (A), which places the 'economic prosperity', at the centre of the Objects of the Act, then proceeds to make mention of 'vitality' and 'liveability'. Immediately the value of the river is commodified; whilst this may appear an innocuous at first, it's important to note that the Yarra Protection Principles within the Birrarung Act do not conceive of any such economic principle which could be mobilized by First Nations. This is a glaring omission as such principles could allow for Indigenous water rights which could assist in economic advancement of First Nations.xvi Instead, their distinct exclusion ensures that no basis for such a right to the use of water, could ever be made out from this legislation. This is especially contentious because of the significant amount of work Indigenous Australians have put into try and realise such Cultural Flows. What is apparent from the Objects in s 5(A) is a liberal conception of the landscape as something to be dominated and exploited for economic gains, not to economically liberate First Nations (Vincent, 1998; de Geus, 2001; Gleeson and Low, 2000; Quilley, 2011). If the intent was for the former, then such a provision could be articulated within the Objects or Principles of the Act. Instead, there is no special dispensation to First Nations to advance under such notions.

Similarly, the Discussion Paper referred to 'improved arrangements' to ensure 'efficient and effective' accountabilities (Yarra River Protection Ministerial Advisory Committee and Department of Environment Land, Water and Planning, 2016). The adoption of these languages reflects a preference for technocracy in the distribution of government power. Paradigmatic of coloniality, classical liberalism is inferred to be directing action, apparent in the deployment of rhetoric of market logics. The assertion of liberal rationalities in the genesis of the Birrarung Act conflicts with the tenets of traditional values and indigenous epistemologies that do not conceive of 'ownership', 'property', and 'marketisation'. We can derive from this that the management of the Birrarung under the new Act is more akin to a wheel in the machinery of capitalist coloniality, than an act of decoloniality.

Section 5(B) of the Birrarung Act aligns with a First Nations conception of the Birrarung and its

parklands as 'one living and integrated natural entity' (Hawker and Murray Lower Darling Rivers Indigenous Nations, 2010, p.2). This follows directly behind s 5(A) of the Act, an alignment reflective of the implied order of importance as determined by the settler-colonial state. Through this lens, the continued domination of the settler-colonial state is obvious; but what is less prevalent is in these flagrant contradictions; there is a separation between the 'rational' (human) and 'nature' – a hallmark of coloniality as Quijano argues (Quijano, 2013). The 'rational' is the settler-colonial state and its order-building; the implied 'irrational' stems from the natural, the Indigenous. This is obvious because of the way the familiar modernist and 'rational' rhetoric is listed as Objects 5(A), whereas the Indigenous conception of one single integrated entity (as founded in Aboriginal episteme) is secondary to this, instead finding itself as Objects 5(B). This silhouette outlines the contours of coloniality so clear within the Birrarung Act.

Furthermore, the use of the term 'environmental significance' is commonly associated with empirical research, and establishes a hierarchy defining that which is considered significant in the environment (and worthy of protection) and that which is not significant. This commodification of values, whilst expedient is problematic because it requires the assimilation of Indigenous values into a settler-colonial paradigm. Assimilation does not equate with recognition of Indigenous epistemologies as equal, because there is no 'more' or 'less' significantly valuable parts of the river systems in Indigenous Australian epistemologies. As Cooper and Jackson note, there is only a 'whole' and singular living entity (Cooper and Jackson, 2008). This is contradictory to the recognition of a single integrated living entity.

In Object s 5(B) of the Act, reference is made to the river being a 'whole entity'. However, this precedes the primary definition of the river as being a 'public park'. Furthermore, no significant reference is made to the Birrarung (and Parklands) being a 'sovereign asset' of the riparian First Nations'.^{xvii} This inclusion subordinates the indigenous conceptions of the Birrarung beneath the colonial constructions of the river, the parkland and the fauna, according to the undergirding logics of coloniality. Indeed, the nation-state retains title over the bed, soil, and banks of the Birrarung (Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.8). Interestingly by identifying itself as the 'protector' of these abstractions, the nation-state implies that had such sovereignty over the Birrarung been handed to First Nations Australians (either via a grant of title over all such land along the banks, and bed of the Birrarung; or by giving legal guardianship of the Birrarung to First Peoples), First Nations would not have been capable of governing the Birrarung appropriately. Would control of the Birrarung by First Nations be in service of the modern nation-states' goals? The

assumption appears to be that it would not, and therefore such a possibility was not considered.

Objects s 5(C) establishes an 'overarching policy and planning framework' to coordinate for the 'use development, and protection' of the Birrarung. In instituting this, before creating the Birrarung Council in Objects s 5(D), the importance of 'development' (presumably 'economic' development as mentioned in Objects A) is reaffirmed. Despite the claims made in Objects s 5(D) of this act, claims which assert the continued protection and preservation of the Birrarung, it is apparent that the ensuing protection of First Nations cultural assets are subject to the continued whims of Objects s 5(C) and the colonial-settler society writ-large. The continuing relevance of economic development in this Birrarung Act are reflective of the broader development agenda inflicted upon First Peoples the world over. Modernist development projects have consistently been mobilized in service of the logics of coloniality, and this should serve as a cautionary tale about the use of seemingly nebulous and innocuous terms in centralised planning legislation.

Unfortunately, paragons of coloniality were also present in the formative MAC Final Report. The MAC Final Report developed the framing for the Birrarung Act as it now stands, and was co-authored by four individuals appointed by the Victorian government (Yarra River Protection Ministerial Advisory Committee et al., 2016, p.2). All of the appointees came from a professional background working as either government bureaucrats, lawyers, architects, or water managers (Yarra River Protection Ministerial Advisory Committee et al., 2016, p.3). As described earlier, the Wurundjeri Council was only invited to submit feedback for the MAC Final Report and not the Discussion Paper.^{xviii} The Wurundjeri Council was also not invited to stakeholder consultations as a key stakeholder (Yarra River Protection Ministerial Advisory Committee et al., 2016, p.4), nor was it engaged when the Ministerial Advisory Committee was appointed (Yarra River Protection Ministerial Advisory Committee et al., 2016, p.4). This approach cannot build intercultural understanding or border epistemologies, primarily because it does not align with the 'co-design' community engagement as above described (Greaves, 2017). As co-design sits is a more intensive level of the public participation to form a border epistemology would require high level engagement with First Nations to conceive of the issues right at the beginning. This would then be broadened into a response which satisfies the concerns of First Australians. This was not the approach taken by the in the MAC Final Report. Although this was remedied somewhat by later engagement of the Wurundjeri Council in the MAC Final Report and then in the Action Plan. Wurundjeri Council representatives stated in their foreword to the Action Plan that their invitation to participate was 'highly significant' and that they hoped

this would mark a 'genuine paradigm shift' to co-designing of decisions and policies (Department of the Environment, Land, Water and Planning, 2017b, p.ⁱⁱⁱ). Nevertheless, without greater awareness of to co-design as an approach to development planning, it will be difficult for this assimilative approach to break-free from its roots in coloniality.

The statutory functions of the Birrarung Council, to only report and audit on the implementation of the Strategic Plan, are another representation of assimilation as opposed to co-design. The Birrarung Council is restricted to only make recommendation on the implementation of the Strategic Plan, reflecting its limited role to make fundamental change. The mandated inclusion of only two indigenous members, out of the twelve members do not equate to a majority of First Nations members on the council; the optics of this appear to show egalitarian reform in the governance of the Birrarung in action. By presenting these progressive credentials, and yet ensuring that the council membership is instead stacked with interest aligned with those of the settler-colonial society the decisions made by the council will have a faux air of legitimacy about them.. Wolfe argues that as simulationist programs of the settler-colonial societies, whereby First Peoples are brought into the settler-colonial legal systems are common (Wolfe, 2006). They suggest that by attempting to cite native advancement as the reasons for this assimilation, a justification for the processes of coloniality are established (Wolfe, 2006). It is important to recognise that the constitution of the council with two First Nations members represents this assimilation of First Nations peoples into the broader legislative processes of 'development' and management of the Birrarung.

Throughout the Act, the scientific research method is relied upon to mediate where specific management practices should be implemented (Department of the Environment, Land, Water and Planning, 2017b), attempting to further subsume Indigenous knowledges within Western empiricism. These methodologies are derived from the age of enlightenment and as such, are premised on the 'abstract universality' of 'truth' in the world: a binary through which it is inferred science can explain reality (Quijano, 2013). Throughout the Birrarung Act references are made to the precautionary principle, implicit in these is the statements is the presumption that empirical data will be relied upon for decision-making (Yarra River Protection Ministerial Advisory Committee et al., 2016; Department of the Environment, Land, Water and Planning, 2017b). This data is often used to then benchmark against the strategic implementation of key performance indicators. These methods for testing and obtaining data are inextricably linked to coloniality (and abstractions of universal rationality), because of the historical circumstances

under which empiricism came to be. As Quijano and Mignolo note, it is irreconcilably biased because of its rooting in the epistemology of Western modernity. As indigenous epistemologies do not have the same contours as empiricism (raw data sets, specific measurements, consistent methodologies, and a lack of easy comparison), these knowledges are considered subsidiary to those which make use of empirical methods. Wolfe's argues that the elimination of indigeneity was most prominently the goal of settler-colonial societies (Wolfe, 2006). This included the erasure of indigenous identities, and indigenous ontology (Wolfe, 2006). This subjugation of episteme by claiming one form of knowing the world as more superior than the other, shows the same elimination Wolfe discusses, in action at this very moment (Wolfe, 2006).

Elimination can also be seen in Section 13: Management Principles. These are in the form of elimination of intercultural understanding. Principle (3) describes that:

(3) 'Implementation of natural resource management should aim for continuous improvement and extend beyond compliance with relevant laws and requirements' (Yarra River Protection (Wilip-gin Birrarung murrn) Act, p.13).

It is curious that strong phrasing such as 'aim for continuous improvement' and 'extend beyond compliance' would be used in conjunctions with the term 'natural resources'. This raises questions over the way in which these natural resources will be managed – are these resources to be expropriated for profit in the future? The use of the term 'resources' is also problematic, because it falls into the lexicon of extractive colonial industries. Without clear definition, the Birrarung Act leaves the onus of defining 'natural resources' up to future – most likely in costly litigious battles. Taken together, Principle (3) implicitly suggests that further intensification of development activities along the river are inevitable. Indeed, the existence of this very principle establishes a specific threshold over which the settler-colonial state inserts itself into the management and de-facto control of that resource. This principle protects not just the nation-state's existing rights to extract values from along the river (as deemed necessary), but also extends this right even further. In extending this right further, it is possible in the foreseeable future it could be legal basis to expand resource extraction.

The fact that the imported British common law is the chosen vehicle for instituting these legal reforms system, and efforts to interface between traditional legal systems and the common law appear so limited raises concern over how 'liberating' this legislative technology might be. The 'legislative backing' of the strategic planning document reflects the translation, assimilation, and (by this fact) the subordination, of traditional legal systems beneath the Australian common law.

Indigenous land tenure legislation exists in both the state, and Commonwealth jurisdictions, and yet it is excluded as a possible avenue to mediate between the Australian legal systems, and indigenous legal systems. Furthermore, in assimilating the Birrarung (First Nations 'sovereign asset') into the common law, the right to refuse development of the Birrarung is brought under scrutiny. True thought it may be that this right for First Nations peoples simply did not exist prior; however, by adopting the logics of coloniality, modernity, and development into plans and legislation, the momentum justifying intervention into the Birrarung is formalized under the pretense of 'advancing' Aboriginal peoples.

Although the Birrarung Act represents a 'lite' attempt at decoloniality, it is under the trajectory of coloniality – in which the coloniser leads, by attempting to decolonise themselves. Mignolo's compares this to the notions of 'emancipation' as opposed to 'liberation', explaining that Hegel's transcendent freedom of subjectivity and critical self-reflexivity informed the concept of individualism (Mignolo, 2013, p.467). This individualism then sought to 'emancipate the individual', allowing autonomy which later came to be associated with liberalism as envisioned by Locke.^{ix} To that end the concept of 'emancipation' cannot escape the epistemology of coloniality because of its theological links with modernism (Mignolo, 2013, p.467). Attempts by the coloniser to adjust their own agency as a matter of self-deconstruction are tawdry, because without disestablishing basis of its' own power and control, the colonizer cannot truly self-deconstruct. Rather than fundamentally seeking to reconceive of reality, the veil is lifted to show the Birrarung Act is more akin to a 'feel good' project rather than addressing the epistemic splits of coloniality.

VII. CONCLUDING REMARKS

There is a great deal that can be improved within this act. It is difficult to conceive of how this legislation can reach the theoretical standards of decoloniality as conceptualized from Wolfe, Mignolo and Quijano's work, without entirely unraveling the foundational hegemon of the settler-colonial society. Nevertheless, this does not appear to be the objective of the analytical tools of Mignolo, Wolfe, or Quijano. The aspiration to endorse a 'pluri-versal' world of knowledges and understanding can begin from places such as border epistemologies, and by developing a discourse of engagement between First Nations Australians and the settler-colonial nation-state.

Despite the challenges to traditional settler-society law and development logics manifested in the Act, it continues to recognise Aboriginal sovereignty in a very limited capacity. It adopts a thoroughly western approach to watercourse management, and it ensures that a minority of members on the Birrarung Council are

indigenous. The advisory committee itself, only serves an advisory role to the minister. The Birrarung Act makes no reference to the traditional legal systems of the First Nations of the Birrarung. Instead, the legislation offers predictability, rationality and formality within the imported Australian legal system.

The thematic questions, developed from the coloniality/decoloniality writings of Quijano, Mignolo, and Wolfe have been responded to in both the affirmative, and the negative. The strategies presented in the Birrarung Act (and its instruments'), are both actively pursuing decoloniality, and furthering settler-colonial hegemon. In certain circumstances science/rationality, and reason are as one; but in other instances they're separate. Traditional knowledges are recognised to be of equal importance in certain statements, and in others there is a very clear privileging of scientific empiricism, and no inclusion of traditional knowledges. The silhouette of modernity and the development agenda can be clearly outlined, and yet the Birrarung Act does try to engage with decoloniality, and intercultural border epistemologies. From these vantages the Birrarung Act does offer a critique of the colonial matrix of power, but only in small actions and statements.

The Birrarung Act does bear the hallmarks vanity, in hawking its egalitarian and progressive qualifications, whilst only promoting marginal change. Nevertheless, a small space is carved out for intercultural understanding, reflecting the possibility of a pluri-versality in logics and reasoning. Small though it may be, there is space for critical insights, and exchanges of cultures and societies.

Ideally the pathway forwards would've been mapped by First Nations taking the lead entirely, and the legislative implemented in collaboration with government. Current practice within specific departments of the Victorian government is to support self-determination and to co-design, and co-create policy with Traditional Owners and other Indigenous communities as evidenced in numerous policy documents (Aboriginal Victoria, 2019a, p.1, b, p.1; Department of the Environment, Land, Water and Planning, 2019b, p.1, a, p.1; Local Government Victoria, 2016). In this respect, whilst it is heartening to see engagement of first peoples in this process, it would be ideal to see further steps towards decoloniality going into the future (whatever these may be).

This paper sought to investigate legislation and its role in shaping cultural norms and systems of knowledges. By applying an analytical lens drawn from the law and development field, specifically coloniality/decoloniality and elimination/assimilation episteme, the asymmetric power relations could be uncovered. The processes of exclusion of First Nations were shown to be more extreme than would otherwise have been exposed using modernist tools of analysis.

The unusual approach of looking at law and development in a first world country (in relation to its First Peoples) shows that the pitfalls of modernism and development continue, if however Janus-faced. They are not restricted to Global South economies, but seem to be applied to the 'other' – most often those not directly engaging with the modernist development agenda.

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Both Indigenous Standpoint Theory, and Feminist Standpoint Theory expect a researched to address their privilege in relation to those they research (Ardill, 2013). At this juncture, the author acknowledges their own biases, which are likely to distort their standpoint, and understanding of phenomena. The author of this paper draws upon Paul Hagemann's standpoint analysis as described in their text 'Denial, Modernity and Exclusion: Indigenous Placelessness in Australia', to inform their own standpoint analysis (Havemann, 2005). As a matter of respect for the First Peoples of Australia, the author identifies themselves as a white, upper-class, male, who has been afforded the opportunity to do this research, due to the many privileges they enjoy. In respecting the traditions of First Australians, and being someone who comes from privilege, entering onto the epistemic 'lands' of these peoples, the author is expected to declare who they are, and what purpose they have. So then, the author makes note that they are writing from a point of privilege, and that they're writing about settler-colonial legislation, and trying to unpick its contents. Again, the author states they're an outsider who does not live through this experience every day. The author also makes note that their education has been formed through a process developed as part of the colonial matrix of power, and this will also likely affect the authors judgements.

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ⁱ The term 'coloniality' is defined further in proceeding paragraphs.

ⁱⁱ 'Inter-cultural' refers to the meeting points of Indigenous and 'modern' societies and cultures, and in this instance refers to areas valued by both the Indigenous and 'modern' societies.

'Border epistemologies', like 'inter-cultural' is knowledge created at the point at which two cultures meet (it doesn't necessarily involve modern and Indigenous societies') (Mignolo, 2013).

ⁱⁱⁱ This term is elaborated further upon in proceeding sections.

^{iv} Funding for infrastructure arrangement as dictated by the plan is also included as part of these arrangements. See generally: Yarra River Protection Ministerial Advisory Committee and Department of Environment Land, Water and Planning (n 4).

^v Due to call-in powers enjoyed by the minister for planning, a number of controversy's have arisen. There are wide latitudes for third parties and individuals to appeal these decisions as they relate to the Victorian Planning Scheme, which are not afforded in the Birrarung Act. Further examples in which controversy has arisen, and the requisite action of community groups in response can be found in Cook et al (2012).

^{vi} 'Being' and 'understanding' referring to the acts of building intercultural knowledge between Indigenous and non-Indigenous peoples; and the mobilisation of this 'intercultural' dialogue into every day practices of living (Mignolo, 2011, p.453).

^{vii} The case which Wolfe refers to in his writing is the *Members of the Yorta Yorta Aboriginal Community v. the State of Victoria & Ors* (2002) case, which narrowed the scope for interpretation and therefore recognition of Indigenous land tenure in Australia hugely in 2002 (Case, 1999; as per: Wolfe, 2006, p.393).

^{viii} 'Processes' refers to agricultural, industrial, engineering, and other such processes which are considered to be the foundations of 'modern' society, this includes areas such as medicine and health (Mignolo, 2011, p.462).

^{ix} It is assumed that 'nature' is all the biological, and ecological values within the landscape and other non-human produced entities – even this definition is somewhat of a fallacy (Yarra River Protection (Wilip-gin Birrarung murrong) Act, p.4).

^x This is a very brief summary of an extremely complicated argument, and further reading can be found in Kanth (2017).

^{xi} It is not within the scope of this essay to debate philosophical arguments over anthropocentrism and deep-ecology – nevertheless – further analysis of the history of separation between man and 'nature' beginning in Judaeo-Christian religions can be found in seen generally in Kanth (2017).

^{xii} Faster recovery times; improved long-term mental health have been associated with access to greenery. There is readings on articles which have established empirical data reflecting these health benefits (Park and Mattson, 2009a; b; Ulrich, 1984).

^{xiii} (Greaves, 2017, p.1 [5]. Source: VAGO based on IAP2. This diagram is produced subject to the Copyright Act (1968). Acknowledgement is made to the original copyright owner (the VAGO). No official connection is claimed between this article and the VAGO. The material is made available without charge or any cost, and the material is not subject to inaccurate, misleading or derogatory treatment.)

^{xiv} Under the Water Act (1989) and the National Water Initiative (2004) provisions were made for indigenous submissions to water plans, overarching documents which manage the way in which water resources are used in water systems, but these were the only spaces in which indigenous voices could be expressed in relation to the management of water. Macpherson writes specifically on this topic (2017).

^{xv} 'Cultural expression' along the Birrarung is defined by Keryn Hawker as being achieved through the maintenance of the health of the riparian corridor and associated ecologies along the river. Part of this expression is found in the health of these environments. Hawker et al. write on this generally (2010).

^{xvi} Indigenous Water Rights can be understood as a legal right ascribed specifically for Indigenous peoples to use in the pursuit of Cultural Flows. For a definition of Cultural Flows, and to understand more generally how Indigenous Water Rights could fit within a framework for Cultural Flows. Nelson et al. discuss this more in depth (2018)

^{xvii} As defined by the Wurundjeri elders who wrote a foreword for the Action Plan (Department of the Environment, Land, Water and Planning, 2017b, p.iii).

^{xviii} As can be gleaned from observing the timeline presented in the Discussion Paper (Yarra River Protection Ministerial Advisory Committee et al., 2016, p.4).

^{xix} This idea came to be found in John Locke's philosophy of liberalism. The time at which it was conceived entailed battles between royalty and bourgeoisie for autonomy and freedom; and so, it came to be associated with the freedom of the elite in America from the tyranny of the British Crown (Mignolo, 2011, p.467).



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Effect of the Wire Arc Additive Manufacturing Process Parameters on the Quality of Steel Components

By Anton A Kulikov, Maria V Grechneva & Andrei E Balanovskiy

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Keywords: *additive manufacturing, wire arc additive manufacturing, gas metal arc welding, process parameters, steel, mechanical properties.*

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Anton A Kulikov^α, Maria V Grechneva^σ & Andrei E Balanovskiy^ρ

Abstract- Wire arc additive manufacturing enables utilizing nearly any metallic alloy for the additive production of the geometrically complex parts and components of large scales. As an increasing number of materials are being used for WAAM, it is fundamental to conduct systematic research on the properties of various metals and alloys. This article presents a study of the influence of process parameters on the quality of the wire arc additively manufactured Sv-08G2S steel. During the experiments, the optimal process parameters were selected for the deposition of even and defect-free beads. The correlation between the process parameters and the bead geometry was determined. Adjustments of the parameters were made during the deposition of the walls consisting of a different number of layers. Once adjustments had been completed, more geometrically complex samples were manufactured. After deposition, the common defects and their possible causes were identified, and recommendations for their elimination were given. The obtained values of the ultimate tensile strength and yield strength of additively deposited steel are within the range and even exceed the characteristics of wrought low-carbon steels. Therefore, the conducted research has demonstrated that the wire arc additively manufactured Sv-08G2S steel provides the necessary quality and mechanical properties required for structural steels.

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I. INTRODUCTION

The popularity of additive manufacturing (AM) and its rapid development are primarily related to the necessity of developing modern cost-effective manufacturing technologies. AM enables high-performance manufacturing of parts with complex geometric shapes. Another significant advantage of AM is a high material utilization rate combined with a low cost of feedstocks.

One of the latest technologies for 3D printing of metal products is wire arc additive manufacturing (WAAM). This technology combines industrial robots with off-the-shelf welding equipment. Thanks to the use of welding wires, the WAAM technology has a huge

potential for printing almost any metal alloys [1-8]. Compared with the traditional subtractive manufacturing (machining), WAAM has a higher performance (40-60% higher), which helps to reduce the time of the finishing machining by 15-20%, depending on the size of the product [9].

The heat source is an electric arc generated between the substrate and the metal wire [10-13]. Welding wires are used as a feedstock material, which is much cheaper than metal powders used in other additive technologies [14-17]. Along with printing new parts, WAAM can also be used for repair and restoration operations [18].

The production of structurally strong, high-quality, reliable parts requires an understanding of the existing technological processes, underlying physical processes, raw materials, process control approaches, causes of various defects, and methods for their elimination. In order to produce parts with pre-set properties, it is instrumental to understand the principles of the microstructure evolution and mechanical properties of metals during the thermal impact.

As steels are still the most common industrial materials, they are of great interest to the WAAM community. On the one hand, the allotropy of iron-based alloys combined with high-temperature gradients makes it possible to produce components with a unique microstructure. On the other hand, alloys that may have different phase compositions depending on the cooling rate, such as martensite and retained austenite in steels with dispersion hardening will be sensitive to different thermal welding cycles. Therefore, steels require thorough research in order to be effectively applied in WAAM technology.

Due to the highly complex nature of metallurgical and welding processes occurring during deposition, many different aspects of the process need to be studied, including process development, process parameters, material quality and performance, the influence of heat input on characteristics of a final part.

This paper reviews the study of the effect of the various process parameters on the quality of the wire arc additively manufactured Sv-08G2S steel. The quality of the deposited steel was evaluated through micrographic analysis, Brinell hardness testing, and tensile testing.

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II. METHODOLOGY

The experimental robotic WAAM complex installed in the Irkutsk National Research Technical University was used to produce samples for this study and shown in Figure 1. The deposition of the wire was

performed by the gas metal arc welding (GMAW) method using a KUKA KR 210 R2700 prime (KUKA robotics, Germany) with the Lorch SpeedPulse S3 mobil welding machine (Lorch, Germany).



Figure 1: Experimental robotic WAAM complex

The Sv-08G2S steel welding wire was used as a feedstock material. The chemical composition of this wire is presented in Table 1.

Table 1: Chemical composition of SV-08G2S wire

C	Si	Mn	Ni	S	P	Cr	N
0.06	0.8	1.9	0.2	0.02	0.02	0.1	0.01

Samples for microstructure analysis were cut across the central line of the deposited layers. Optical microscopy of the mechanically polished samples was performed in a cross-section. Samples were etched with Keller's reagent (2 ml HF, 3 ml HCl, and 5 ml HNO₃ in 190 ml of water) to reveal the structure of the metal and grains. Electron microscopic studies were carried out on the basis of the Irkutsk National Research Technical University using a scanning electron microscope JIB-4501 JEOL multi-beam system equipped with an electronic and ion gun JIB-4501, completed with a nitrogen-free system of energy-dispersive microanalysis. The results were analyzed using the Channel 5 software package developed by Oxford Instruments. For these purposes, test samples had additionally passed the electro-polishing stage. The size of the scanning area for samples was 620 microns. The grain was taken as

an area surrounded by large-angle borders, i.e. the value of the limit angle was set to 15°.

The microanalysis was followed by the Brinell hardness testing along the length of samples. The measurements present results of evaluating the hardness of sectors of samples from the first layer to the last. The HBRV – 187.5 hardness testing machine was used for measurements. Samples were used under a load of 7kH for 10 seconds. The HBRV – 187.5 hardness testing machine uses a rotational type of load change mechanism, as well as an optical measurement display system and a measuring microscope mounted on the device body. Polished (Ra < 0.04 microns) balls made of SHX15 steel with a nominal diameter of 5 mm were used as penetrators. The CDM-20 tensile testing machine was used for the tensile testing of samples.

III. CASE STUDY

The parameters that have a major effect on the layer formation are found to be the torch travel speed, wire feed rate, and welding current. The selection of welding current was based on a wire diameter of 0.8 mm. The most suitable and optimal welding current for

such diameter lies in the range of 100-120 A. Adjustment of these parameters allows achieving the desired quality of a deposited bead, its geometry, and the performance of the process Figure 2 illustrates five different beads produced at various deposition speeds.



Figure 2: Deposited beads using different process parameters

As can be seen from Table 2, the width of the bead varies depending on the torch travel speed. Bead №1 was deposited at a speed of 0.005 m/sec, which resulted in a too narrow bead with uneven melting of the metal. Applying this speed for the deposition of a real part, the accuracy of the geometric dimensions will be low, and the process of additive manufacturing as such

will be unstable and difficult to control. Increasing the welding current while maintaining the same deposition speed did not give a positive result since it was necessary to increase the wire feed speed as well which led to the intensive scattering of the molten metal and the formation of an uneven geometry of the bead.

Table 2: Relationship between process parameters and the geometry of the deposited beads

Weld bead, №	Width, mm	Height, mm	Welding current, A	Welding Voltage, V	Wire feed rate, m/min	Torch travel speed, m/sec	Stickout distance, mm
1	4	2	100	26	4	0.005	14
2	6	3	120	28	5	0.004	13
3	8	3	120	28	4.5	0.003	11
4	10	2	120	28	4.5	0.002	11
5	12	2	120	28	4.5	0.001	11

When depositing bead №2, the deposition speed was reduced to 0.004 m/sec at a welding current of 120A. The reduction of the speed of deposition contributed to the formation of a bead of high quality since the metal was melted evenly with small distortions along the central axis. However, applying such deposition parameters, the height of the bead along the central line is significantly bigger than the height of the bead on the sides. It will negatively affect the formation

of the next layers since the metal will not be able to evenly overlap the uneven surface of the previous layer. As a result, the metal will flow along the sides of the layer, leaving the centerline unfilled. In this case, it will be quite difficult to control the process and achieve the desired accuracy of the dimensions of real parts. Further reduction of the speed to 0.003 m/sec during the deposition of the bead №3 gave the most promising result.

The formation of the bead №3 is satisfactory enough; the layer itself is straight having the least distortion. The height of the bead is optimal and will contribute to the qualitative deposition of subsequent layers. Utilizing these parameters, it will be possible to predict the behavior of the metal during the deposition process and achieve dimensional accuracy.

The subsequent reduction of the speed to 0.002 and 0.001 m/sec during the deposition of samples №4 and №5 resulted in the production of the widest beads. Excessive heat input at these speeds leads to

overheating of the metal and the formation of an inhomogeneous structure, which will inevitably contribute to the formation of defects. Additionally, applying such parameters, it will be quite difficult to achieve the dimension accuracy and quality of the deposited surface.

Ultimately, a linear relationship between the print speed (torch travel speed) and the width of the deposited bead was determined during the experiments (see Figure 3).

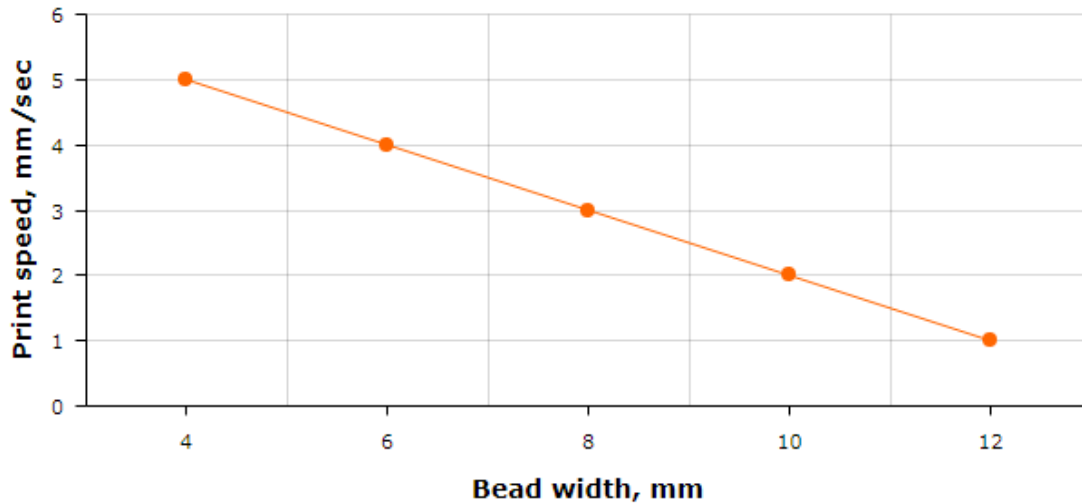


Figure 3: Correlation between print speed and bead width

Thus, the most optimal parameters for the deposition during this experiment are the following: welding current – 100 A, welding voltage – 26 V, wire feed rate – 4,5 m/min, torch travel speed – 0,003 m/sec, stick out distance – 11 mm). For the deposition of multi-layer samples, a more precise parameter setting will be

required during the layering process, depending on the geometry of the resulting part. Figure 4 illustrates the multi-layer walls deposited using the above-mentioned parameters. Table 3 illustrates the obtained geometry of the walls.



Figure 4: Deposited walls

Table 3: Characteristics of the deposited walls

Wall, №	Number of layers	Height, mm	Length, mm	Wall thickness, mm	Welding current, A	Welding Voltage, V	Wire feed rate, m/min	Torch travel speed, m/sec	Stickout distance, mm
1	13	27	100	8	100	26	4.5	0.003	11
2	10	20	100	9	100	26	4.5	0.003	11
3	10	20	100	9	100	26	4.5	0.003	11

As can be seen from Table 3, the average thickness of one layer was 2 mm. The deposition speed of 0.003 m/sec is truly applicable for the deposition of even and fairly accurate layers, but the defects are still

present. The most noticeable defects are the spreading of the metal and the slope of the wall at the end of the layer, which was the result of constant and severe heat input during the deposition process (see Figure 5).

*Figure 5:* Slope at the end of the wall

Furthermore, there are elements of non-molten wire and splashes of metal. Some layers are deposited with a slight offset relative to the central axis of the wall, which leads to uneven overall wall thickness. To obtain a more accurate geometry and reduce defects, it is necessary to control the heat input and constantly adjust the parameters during the deposition process.

During the course of the further experiment, a box with dimensions of 60x60 mm was deposited, the number of layers is 15, and the total height is 30 mm (see Figure 6). The average value of the layer thickness of 2 mm, determined in previous experiments, is also preserved during the deposition of a sample with a more complex geometric shape.

*Figure 6:* Deposited box

Layers' deposition in a square-shaped sample differs from that in the wall due to the presence of angles and the constant change of the movement trajectory of the welding torch. Since the torch was moving along a trajectory consisting of 4 linear movements, there were minor stoppages of the torch in the corners of the square. This has led to a slight widening of the beads at the corners, but this is not an issue since post-process machining will help to correct the situation. Essentially, the formation of a square-shaped part is quite successful, the deviation from the

specified dimensions are within the allowance for machining, which indicates the potential of WAAM technology for production parts of the complex angular shape.

Then, the cylindrical samples were deposited (see Figure 7). Cylinder №1 has a diameter of 80 mm and consists of 11 layers with an overall height of 22 mm. Cylinder №2 has a diameter of 50 mm and consists of 24 layers with an overall height of 48 mm.



Figure 7: Deposited cylinders

The previously defined layer height of 2 mm remains unchanged during the deposition of cylindrical shaped samples. A cylinder with a larger diameter has a more even bead shape and has less distortion over the entire length of the layer in comparison with a cylinder with a smaller diameter. A special effect on the process of forming the cylinder has the choice of the point where the deposition of the next layer should start. Since the deposition of each subsequent layer began at one point, a small roll was formed at this very place, which led to an uneven height of the cylinder and a broadening of the wall at this point. In order to eliminate this defect, it is necessary to change the start point of the deposition of

each subsequent layer or to reduce the dwell time of the welding torch right before the deposition of the next layer.

The next step was to test the selected process parameters for printing more complex parts. The square-to-cylinder body is presented in Figure 8. The first layers of the body are box-shaped. Then, with each successive layer, the robot smoothed out the corners and switched to a cylindrical trajectory. The diameter of the cylinder was also constantly changing. A spiral motion algorithm was set for the torch movement. Such an approach made it possible to avoid stoppages of the torch when switching to a new layer and to increase the

performance of the deposition process since the robot carried out the whole trajectory in one movement. The deposition process took 1 hour, and the body has the

following dimensions: diameter of 70 mm, height of 120 mm, number of layers 60.



Figure 8: Square-to-cylinder body

The next stage of the research was to additively manufacture a real functional machine part using the abovementioned process parameters and taking into consideration the peculiarities of printing a square-to-cylinder body.

As a traditional manufacturing process of a compressor impeller is costly and labor-consuming due

to its complex geometry, this component was chosen as the next test sample. The scaled-down prototype of a compressor impeller was printed for 40 minutes and presented in Figure 9. It comprises 15 layers and has the following dimensions: diameter of 80 mm, height of 30 mm [21].



Figure 9: Compressor impeller prototype

IV. MICROSTRUCTURAL ANALYSIS

Preparation of the sample (see Figure 10) for micro structural analysis includes the following stages:

- rough grinding;
- final grinding;
- polishing;
- etching.

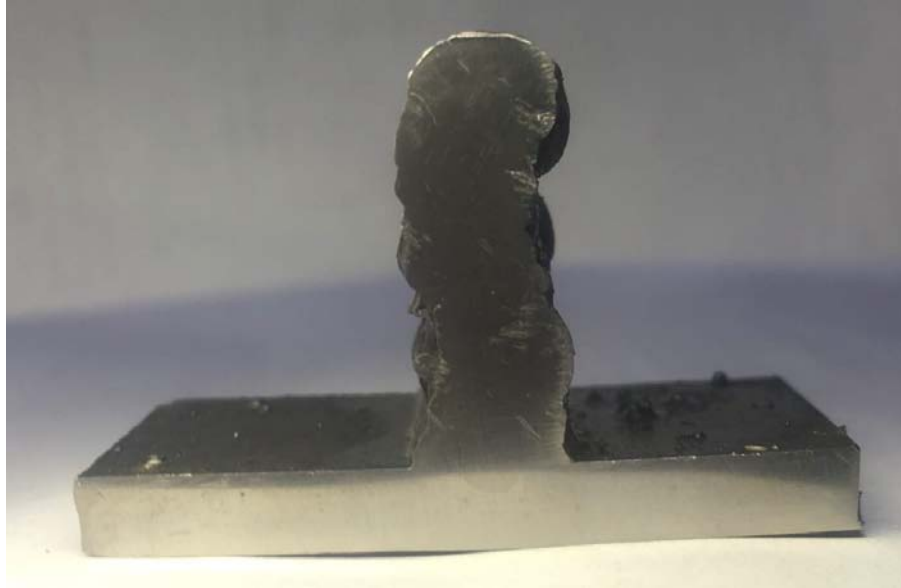


Figure 10: Sample for microstructural analysis

Rough grinding is performed for the leveling of a surface of the sample using an engineer's file. Then a final grinding follows. Final grinding is performed to minimize surface imperfections using abrasive paper of decreasing grain size. Corundum, carborundum, and other solids are used as abrasives deposited on abrasive papers.

The next stage of preparation is polishing, which is necessary for the final alignment of the surface of the sample. Polishing is carried out using a polishing machine, the working body of which is a rotating disk covered with fabric.

Etching of the polished sample is performed to reveal a complete picture of the microstructure (grain

shape and size, presence of phases, structural components). Before etching, the surface of the sample is degreased with alcohol. The sample is etched with Keller's reagent (2 ml HF, 3 ml HCl, and 5 ml HNO₃ in 190 ml of water) for 10-20 seconds. After etching, the sample is washed with water and dried with filter paper.

The sample for microstructural analysis can be divided into 3 sectors: lower, middle, and upper (see Figure 11). The lower sector contacts the cold surface of the substrate metal and experiences a certain heat drop. The metal of the middle sector is characterized by a lower temperature difference since the weld beads of this sector are deposited on the preheated metal of the previous beads.

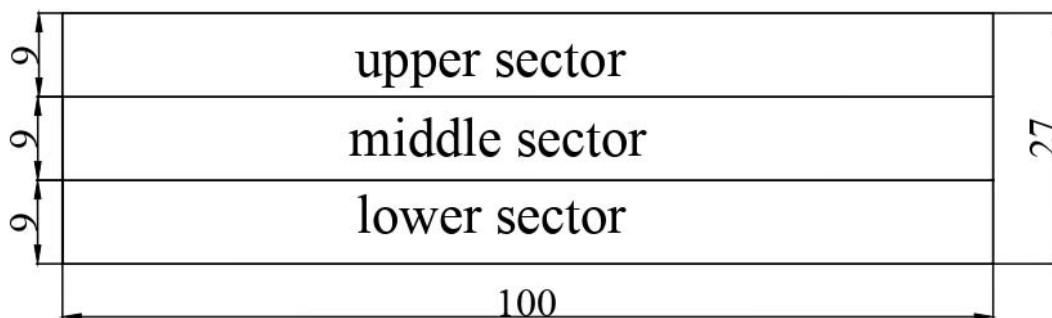


Figure 11: Sectors of the sample

Figure 12 illustrates the microstructure of the lower sector. Equiaxed grains with inclusions of thin lamellas are observed in this sector [19, 20].



Figure 12: The microstructure of the lower sector (ferrite+perlite)

Since the metal is deposited on a cold substrate, the first beads experience a significant temperature difference. This contributes to the formation of a microstructure with ferrite grains and inclusions of lamellar perlite. The formation of ferrite with an equiaxed grain shape with inclusions of lamellar perlite is typical for low-carbon steel, which is the welding wire Sv-08G2S.

Figure 13 illustrates the microstructure of the middle sector. The middle sector is characterized by equiaxed ferrite grains without any inclusions. The microstructure shows that the ferrite of the middle sector has a more coarse-grained structure than in the lower sector. This is due to a higher temperature difference in the lower sector compared with the middle one.



Figure 13: The microstructure of the middle sector (ferrite)

The metal of the middle sector cools slower than that of the upper sector, so its thermal gradient is lower than that in the lower sector. The metal of the lower sector also cools slower than the metal of the upper sector, which results in the formation of ferrite.

The presence of lamellar perlite is explained by a less sharp temperature drop due to the presence of a cold substrate compared with air cooling in the upper sector. Figure 14 illustrates the microstructure of the upper sector.

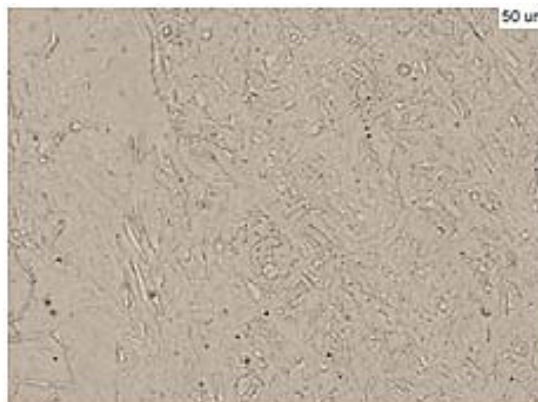


Figure 14: The microstructure of the upper sector (bainite)

As mentioned earlier, it is in this area that a higher temperature drop is observed, so the metal microstructure in this sector is significantly different from others and has a predominantly lamellar structure. In particular, it should be noted that this microstructure is bainite, which is a mixture of ferrite and cementite. Since cooling begins at a temperature of about 70 °C above the critical temperature for the steel used, the growth of ferrite particles devoid of carbon occurs. Since the carbon in ferrite is contained in smaller amounts, it passes to the upper sections and the lamellas are filled with carbon.

It is also worth noting that due to the effect of reheating during the deposition of layers, it is possible to achieve the formation of different microstructures along the height of the sample. This enables adjusting the

microstructure between ferrite and bainite to obtain the necessary mechanical properties of the product by alternating cooling cycles after the deposition of one or more layers [22].

V. HARDNESS TESTING

Figure 15 illustrates a diagram with Brinell hardness values. The results obtained show the hardness values in the direction from the lower to the upper sector. The highest values of hardness are observed in the sector with the bainite structure. It is worth noting the almost complete absence of pores, which is a significant advantage in comparison with other additive technologies used for the production of metal products.

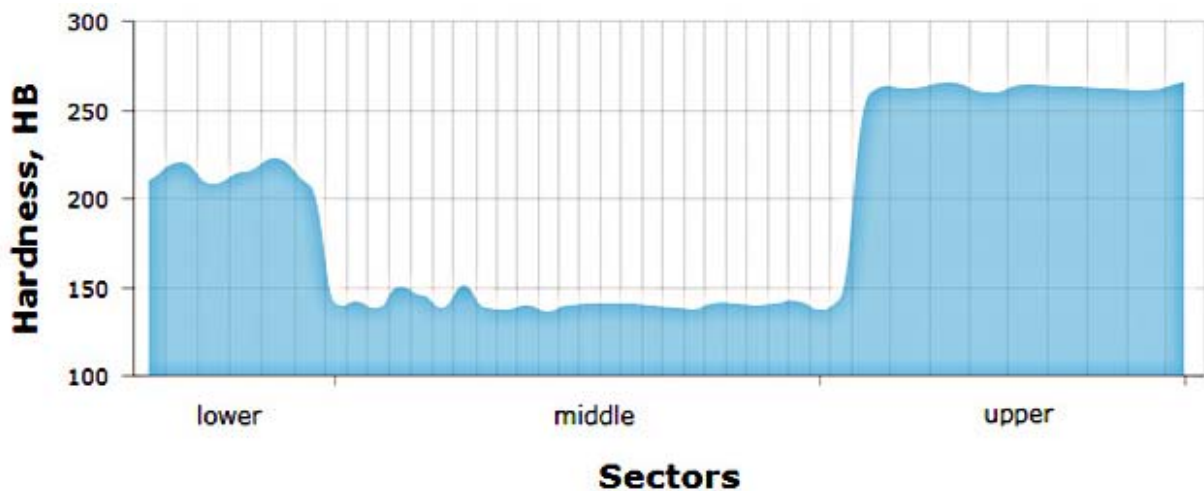


Figure 15: Hardness diagram

The results of hardness measurements confirm the formation of various structures in the sample sectors. Thus, the lower sector, where the structure of ferrite with inclusions of lamellar perlite was formed, has a hardness of 200-220 HB. Higher hardness values of the lower sector compared to the middle sector occur due to inclusions of lamellar perlite.

The middle sector has a purely ferritic structure, which is proved by the lowest hardness values compared with all other sectors. Ferrite is soft and plastic. Ferrite hardness values are in the range of 130-150 HB.

The highest hardness values (260 HB) were found in the upper sector. The bainite structure provides high hardness and strength with high plasticity [22].

VI. TENSILE TESTING

The tensile diagram (see Figure 16) shows the dependence of the elongation of the sample on the longitudinal tensile force.

The diagram has four distinctive areas:

OA – proportionality area (0-350 MPa);

AB – elasticity area (350-360 MPa);

BC – yield point area (360-405 MPa);

CD – hardening area (405-577 MPa);

DE – failure area (577-432 MPa).

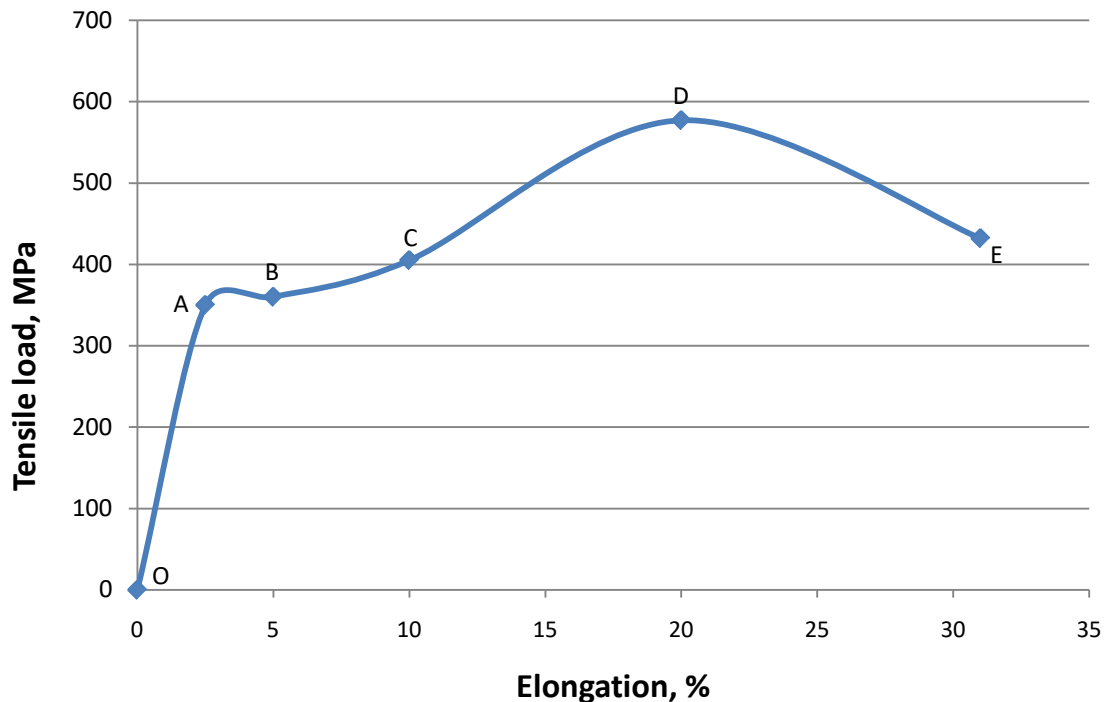


Figure 16: Tensile diagram

At the very beginning of the tensile test, the tensile force, and therefore the deformation of the sample, is zero, so the diagram begins at the intersection of the respective axes (point O).

In the OA area, the diagram is drawn as a straight line. This indicates that in this segment of the diagram, the deformations grow in proportion to the increasing load.

Once point A passed, the diagram abruptly changes its direction, and in the AB area the line runs almost parallel to the stretching axis for some time, that is, the deformations increase at almost the same load value.

At this point, irreversible changes begin to occur in the metal of the sample. The crystal lattice of the metal is rebuilt. At the same time, the effect of self-strengthening is observed.

After increasing the strength of the sample material, the diagram goes up again (BC area) and at point D the tensile force reaches the maximum value. At this point, a local thinning appears in the working part of the test sample, caused by violations of the material structure (the formation of voids, microcracks, etc.).

Due to thinning, and therefore reducing the cross-sectional area of the sample, the tensile force required to stretch it is reduced, and the curve of the diagram goes down.

The sample breaks at point E which is the thinning zone.

Mechanical properties of the WAAM Sv-08G2S steel and wrought low carbon steels with comparable chemical compositions are shown in Table 4.

Table 4: Mechanical properties of steels

Steel grade	Test temperature, °C	YS, MPA	UTS, MPA	Elongation, %	Contraction, %
WAAM Sv-08G2S	20	405	577	31	59
09G2S	20	265-385	430-490	17-31	56-63
09G2T	20				
09G2DT	20				
10G2S1	20	335	485	35	75

As can be seen from the table, the mechanical properties of the wire arc additively manufactured Sv-

08G2S steel meet the properties of conventional wrought low-carbon steels and even exceed them [22].

VII. DISCUSSION

In order to improve the stability of the process, eliminate and completely reduce the number of defects in the deposition process, as well as to achieve the accuracy of the deposited parts, it is paramount to determine the correct process parameters. Since a one-time parameter setting is inadequate for obtaining a high-quality part, monitoring and controlling of all parameters is required during the actual deposition process. To do this, appropriate sensors and a video camera with special light filters are needed to be integrated into the existing WAAM complex to remotely monitor and control the process. Moreover, to improve the quality of deposited beads, it is imperative to utilize shielding gases of higher quality. Carbon dioxide alone is not able to provide the necessary quality, so it is preferable to use a mixture of argon and carbon dioxide. To increase the metal deposit factor and hence the WAAM process performance, the wire diameter should be increased from 0.8 to 1-1.2 mm. For the production of real functional parts, it is vital to implement advanced programmable welding machines that allow adjusting the process parameters directly from the robot control interface.

VIII. CONCLUSIONS

This article presents the results of the study of the influence of process parameters on the quality of steel components. During the course of the experiment, the relationship between the deposition speed and the geometry of the resulting bead was obtained. The most optimal torch travel speed for the deposition of steel parts using a 0.8 mm wire is 0.003 m/sec at a welding current of 100A. This speed allows achieving the best bead formation with the least distortion. The deposition process itself is quite stable and allows producing beads with approximately the same geometry. At this speed, all layers of the samples are of 2 mm thickness. The most common defects were detected during the deposition of walls, square, and cylindrical samples. Due to the constant and repeated heat input, the geometry of the bead at the beginning and end of the layer is different, which leads to the formation of a slope at the end of the wall. Additionally, there are elements of non-molten wire and splashes of metal. During the deposition of square and cylindrical samples, noticeable defects are unevennesses and widenings at the transition points of the layers, which is caused by the peculiarity of the torch movement. In order to eliminate these defects, it is necessary to develop a path-planning program for more effective planning of the torch movement trajectory. In general, the parameters determined during the experiments can be used for the deposition of real parts prototypes. Further adjustment of the parameters will be required during the actual deposition process to achieve better results.

Based on the results of the study of the microstructure and mechanical properties of the wire arc additively manufactured Sv-08G2S steel, the following conclusions can be drawn:

- The structure of the Sv-08G2S metal can be divided into three sectors depending on the formed microstructure. The lower sector is characterized by a ferritic structure with inclusions of lamellar perlite. The middle sector is characterized by a purely ferritic structure with equiaxed grains. The upper sector is characterized by a lamellar structure of bainite.
- Differences in the microstructure of the sectors are due to various temperature differences and heat input experienced by different deposited beads. In particular, the metal of the upper sector experiences a stronger temperature drop due to the difference in air temperature and the temperature of the lower layers.
- The lower sector is characterized by the presence of smaller particles, so the metal in this sector experiences stronger temperature differences compared to the metal in the middle sector, which is characterized by a larger grain.
- The results of the Brinell hardness study confirm the presence of various microstructures. The hardest was the upper sector, which has a bainite structure.
- The results of tensile testing of samples made of Sv-08G2S steel showed mechanical properties that are comparable and even superior to those of conventional wrought low-carbon steels.

Thus, this steel can be used for wire arc additive manufacturing of steel parts, since the resulting mechanical properties meet the requirements for structural steels.

Also, based on the results of the research, it is possible to develop a technology to obtain the necessary structure of ferrite/bainite in accordance with the requirements for the manufacturing part. Obtaining the necessary microstructure can be achieved by alternating cooling cycles and deposition cycles.

Author Contribution

Anton A. Kulikov performed the experiments, conducted the microstructural analysis, mechanical properties testing, and wrote the paper. Maria V. Grechneva contributed to the microstructure and mechanical properties analysis. Andrei E. Balanovskiy carried out the overall project management and participated in the discussion of the results.

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Establishing a Cultural Flows Commission: A Framework for Joint Action on Indigenous Water Rights

By Elliott Leonard Provis

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Abstract- The enactment of the Native Title Act 1993 (Cth) (hereinafter 'the Act') is the most significant change that has occurred in Australian property law in the past 27 years. A much-celebrated milestone, the Act formally recognized traditional Indigenous legal systems and introduced legal pluralism into Australia's legal system. However, in practice, the native title system remains beset with problems. One of the key issues is native title's failure to protect Indigenous water rights. 'Cultural Flows' is a policy framework conceived of by Indigenous peoples to further advance Indigenous water rights and to include Indigenous voices in water planning and management. This paper proposes the creation of a joint Cultural Flows Commission to assist in implementing Cultural Flows. The paper explores how an intergovernmental agreement could be used to establish the Commission and how the Commission could play a vital role in reforming water law and policy to advance Indigenous self-determination in Australia. Most importantly, the Commission would address the many calls for 'national focus' when implementing Cultural Flows.

Keywords: *native title, cultural flows, aqua nullius, indigenous australians, water rights, land rights.*

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I. INTRODUCTION

Australia's landscape is defined by a complex variety of biospheres, including a wide range of water-dependent ecosystems. The diversity of the landscape is reflected in the myriad of different Indigenous societies, cultures and legal systems present in Australia. Aboriginal and Torres Strait Islander peoples maintain a special relationship with both land and water. Water systems hold deep cultural significance and have various uses under Indigenous law (Cooper & Jackson 2008, p. 54; Marshall & Kirby 2017, p. 2). This connection to water is characterised by customary rights and custodianship of water resources that extends beyond surface waters to include underground waters too (Cooper & Jackson 2008, p. 54). Until relatively recently, the dispossession of Indigenous peoples from their land and waters has consistently featured in Australia's history. The High

Court's decision in the 1992 case, *Mabo v The State of Queensland and Ors* [No. 2], overturned the legal doctrine of terra nullius and formally recognized Indigenous land rights for the first time (Mason et al. 1992). Consequently, the Commonwealth Parliament passed the Native Title Act 1993 (Cth). Although an important victory for Indigenous Australia at the time, in many respects, the native title system has failed to deliver as much change as hoped.

Indigenous property rights over water remains a highly disputed topic in Australian law. Section 223 of the Native Title Act (hereinafter 'NTA') states that native title means 'the communal, group or individual rights and interests of Aboriginal peoples or Torres Strait Islanders in relation to land or waters'. Despite this, jurisprudence on native title has not readily recognised Indigenous rights and interests in water resources. Some allege that in practice, there remains an unofficial 'doctrine of aqua nullius' with respect to Indigenous water rights that must be overturned (Marshall & Kirby 2017, p. 48). In addition to the degradation of the environment, failure to recognise Indigenous water rights contributes to the extreme disadvantages in health, wealth creation and wellbeing experienced by Indigenous peoples, including the poor quality of water resources relied upon to sustain some Indigenous communities (Marshall & Kirby 2017, p. 7; Mitrou et al. 2014; Wensing & Porter 2016).

There are several factors that have complicated Indigenous water rights. First are the fundamental epistemic differences (perhaps even incompatibilities), that exist between Indigenous and Western legal, cultural and philosophical concepts of property and ownership.¹ Australia's legal system was built on Western knowledge and ideals, which influence the creation and interpretation of statutes, judicial precedents and decision-making at all levels of government. The Western concept of property ownership as a 'bundle of rights' (Arnold 2002, p. 281;

¹ For further explanation on these epistemic incompatibilities, and the difficulties these present when building understanding between Indigenous peoples and the modernist settle-colonial state see generally:

Armstrong (2002); Mignolo (2013); Mignolo (2011); Mignolo (2017); Quijano (2000); Quijano (2013); and Wolfe (2006)

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as per Marshall & Kirby 2017), is alien to the values of country and communal custodianship so prevalent in Indigenous law (Gammage 2012; Pascoe 2014; Port of Melbourne Corporation 2012; Porter & Barry 2016). There is limited common ground between the two value systems (Marshall & Kirby 2017, p. 156). Native title is one of the key areas where they interact and where this conflict is most evident (Pearson 1997).

Currently, the native title system only recognises 'basic landholder rights'. The Act does not mention rights to use water for commercial purposes or communal rights to water, and jurisprudence has made the recognition of such rights under the common law exceedingly difficult (Blackshield 2007; Macpherson 2017, 2019; Marshall & Kirby 2017). Even if communal rights were to be recognised, the compensation available under the Act would not be struggle to be of a sufficient quantity to be reparative for the loss of beneficial ownership of water resources. Furthermore, this would not be a recognition of an Indigenous water right – merely compensation from the extinguishment of this right.

Misinterpretations of Indigenous values and simplistic understandings of 'traditional' uses of water have made various attempts at law reform ineffective (Marshall & Kirby 2017, p. 8). Reforms to the NTA have progressively narrowed the scope for recognising title, as have changes to state and territory-based Indigenous land tenure legislation (Macpherson 2017; O'Bryan 2017). Deficiencies in the legislation have made it difficult for the judiciary to recognise Indigenous water rights in the current legal framework (Blackshield 2007; Macpherson 2017). The courts have also restricted the scope of native title and taken a narrow approach to how native title claims should be processed. The High Court's decision in *The Members of the Yorta Yorta Aboriginal Community v. The State of Victoria & Ors* in December 2002 is an example of how adopting a narrow interpretation of rights led to a finding that native title had been extinguished. Of the approximately 350 native title determinations made thus far, in none have the courts recognised Indigenous rights to use water for commercial consumptive purposes (Macpherson 2017, p. 15). As Jackson et al. (2019, p. 3) surmise, water law and policy in Australia have narrowly prescribed Indigenous rights and therefore, have limited capacity to deliver socioeconomic benefits. Some have gone as far as to characterise the native title determination process as being a regime of extinguishment, rather than recognition (Wensing & Porter 2016).

Another ongoing challenge is the complex interaction between federal, state and territory water legislation and the National Water Initiative (hereinafter 'NWI'). Agreed in 2004, the NWI is an intergovernmental agreement between Commonwealth, state and territory governments that established a water management reform framework and action plan, driven by 'the

continuing national imperative to increase the productivity and efficiency of Australia's water use, the need to service rural and urban communities, and to ensure the health of river and groundwater systems by establishing clear pathways to return all systems to environmentally sustainable levels of extraction' (Commonwealth Parliament of Australia et al. 2004; Department of Agriculture, Water and Environment 2004, p. 1). The NWI introduced the 'unbundling' of property rights over land from water rights, making them separate unmodified legal interests. This means that native title claimants' land rights, if recognised, no longer include rights to the water resources on their land (Macpherson 2017, pp. 4–5). Instead, water access entitlements must be purchased on the water market.

To remedy these problems, fundamental change must be pursued. Some have called for a national discussion over the sharing of water resources and a national response based on a dialogue with all the stakeholders (Marshall & Kirby 2017, p. 162). Others argue that Indigenous peoples should be given 'full jurisdiction' over the use of their resources (Macpherson 2019, p. 215). Central to proposals to redress inequities experienced by the Indigenous communities is 'Cultural Flows', a framework developed by Murray and Lower Darling Rivers Indigenous Nations (hereinafter 'MLDRIN') to recognise and promote Indigenous water rights and self-determination. In Part I, Article 1 of the 'Echuca Declaration', MLDRIN defined Cultural Flows as:

"... Water entitlements that are legally and beneficially owned by the Indigenous Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Indigenous Nations" (Murray and Lower Darling Rivers Indigenous Nations 2007, p. 2).

The 2014 'Independent Review of the Water Act 2007' made three recommendations in relation to First Nations and the NWI, each of which called for greater Indigenous engagement in the decision-making process for water governance and management plans (Morton et al. 2014). However, little action has been made by the government in implementing these recommendations. Addressing Cultural Flows could provide the means to do improve upon the deficiencies noted in the report.

Purpose and scope of this paper

Drawing upon the law and policy approaches proposed by Nelson et al. (2018, p. 6), this paper argues that implementing Cultural Flows is an important step forwards for Indigenous self-determination, one that could play a key role in improving socioeconomic outcomes for Indigenous communities and in 'closing the gap' between Indigenous Australia and the rest of

the country.² One way to achieve this is through an intergovernmental agreement to establish a joint Cultural Flows Commission. This Commission would engage with Commonwealth, state, territory and local governments on water issues. Most importantly, it would seek leadership and direct involvement from First Nations as a body politic. The Commission would make recommendations for law and policy reforms, particularly with respect to the NTA, water legislation and the NWI. It would also undertake research into how Indigenous and Western concepts of property law could be better integrated. Other political measures, like treaties and an Indigenous 'voice' to parliament, could assist and support the implementation of Cultural Flows but this process would not be contingent upon their creation.

It is not within the scope of this paper to lay out an exact blueprint for the legislative changes required, nor how water entitlements should be managed by or on behalf of Indigenous peoples. The aim of this paper is to explore one approach to implementing Cultural Flows, through a Cultural Flows Commission. While there is no single 'silver bullet' solution for Indigenous water rights—because each First Nation has its own legal system and water values, and each jurisdiction has its own legal idiosyncrasies—a Cultural Flows Commission would provide an effective starting point.

The analysis and recommendations in this paper are based on the author's socio-legal research and in-depth academic literature review on native title and water management. The author acknowledges the biases that may be inherent in this paper stemming from its lack of quantitative and qualitative empirical research conducted in collaboration with Indigenous peoples. The resources to conduct such research were not available to the author in the creation of this paper. Further, as a matter of respect for the Indigenous peoples of Australia, the author identifies themselves as a white, upper-class male who is writing from a position of privilege and who has not lived the Indigenous Australian experience.

II. AN INTERGOVERNMENTAL AGREEMENT ON CULTURAL FLOWS

In Australia, there is currently no national treaty between First Nations and the Commonwealth. Similarly, there is no national charter on human rights (although some jurisdictions have their own human rights legislation). Legal researchers consider it significant that Australia has opted to pursue anti-discrimination

legislation rather than rights-affirming legislation (Williams 1999, p. 3). This poses a challenge for Cultural Flows, which will likely require changes to rights-based legislation. Nelson et al.(2018, p. 6) propose a three pronged approach:

1. Creating clear legal protections and definitions around Indigenous water rights
2. Reforming laws that effect water rights and the broader landscape (such as land use, planning, heritage and environmental protection laws)
3. Implementing changes to water governance, including increased Indigenous engagement in water planning.

In particular, water legislation must be reformed to recognise Indigenous peoples as a body-politic with specific rights that enable them to be consumptive users of water resources(Nelson et al. 2018). Instead of current arrangements, which consider Indigenous peoples as only having either basic land holder rights, or as environmental and other public benefit outcomes water users (Nelson et al. 2018).Although the courts have recognised native title rights and interests in water for "personal, domestic, and non-commercial communal purposes" (best equated with basic landholder rights), they have not been willing to recognise rights and interests in water beyond this (Rares 2014; as per Macpherson 2017, p. 14). A water access entitlement of the scale described in the Echuca Declaration, would be akin to a consumptive use. Evidently this is a larger amount of water than the equivalent basic landholder rights water access entitlement would be capable of providing. Jurisprudence has not recognised the existence of such rights under Native title(Rares 2014; as per Macpherson 2017, p. 14).

The Initiative explains that only water allocated for holders of Native title for traditional cultural purposes, will be accounted for (Macpherson 2017, p. 6). Cultural Flows are not considered 'traditional' because they would require entitlements to large amounts of water – entitlements greater than those given under basic landholder/stock and domestic rights. This ensures Native title rights and interests in water resources will be relegated to basic landholder rights and entitlements congruent with environmental and public benefit outcomes, and not consumptive uses.

An intergovernmental agreement between the Commonwealth, states, territories and First Nations would provide the framework for a collaborative national response to these issues. Inter governmental agreements can take many forms. Some agreements are scheduled to legislation; some are approved, ratified or authorised by legislation in some other way; whilst some are tabled in parliament(Saunders 2005, p. 7). In some instances, an agreement is created through joint legislation implemented by a lead state, which the remaining state, territory and Commonwealth

² The 'Closing the Gap' report series is a number of reports produced annually that detail the progress of the Australian Government in achieving targets set in 2008 (Australian Government & National Indigenous Australians Agency 2019; Australian Indigenous Health Info Net 2016, 2016)

parliaments recognise through mirror legislation (Saunders 2005, p. 7). Complimentary Applied Laws,³ and Mirror Legislation,⁴ are the two legislative techniques recommended for the intergovernmental agreement.

a) *Benefits of an intergovernmental agreement*

There are many Australian examples of successful intergovernmental agreements for joint action, and there are already precedents for joint management of Indigenous water resources, such as the Kungun Ngarrindjeri Yunan Agreement (Hemming et al. 2017). An intergovernmental agreement based on the Complimentary Applied Laws approach, allows all levels of government to coordinate and cooperate with one another, which is why this approach is so desirable when dealing with a national issue that may be politically divisive (Painter 1998). As a national response is called for, an intergovernmental agreement on creating a Cultural Flows Commission is worthy of consideration. Some of the key benefits of creating the Cultural Flows Commission through an intergovernmental agreement are:

1. Intergovernmental agreements can circumvent certain constitutional restrictions on Commonwealth spending, as states can simply accept payments made to them by the federal government. The funding arrangements in an intergovernmental agreement provide a clear path for Commonwealth funding to states. In addition, an agreement provides accountability for state and territory spending, preventing states from procuring funding from the Commonwealth for specific projects and diverting it elsewhere (Painter 1998). The Commission will require government funding of some description and an intergovernmental agreement would provide the appropriate pathways.
2. Intergovernmental agreements allow the parties to pool executive capabilities, financial reporting and administrative oversight, which promotes efficiency (Painter 1998, p. 100).
3. Thanks to consistent advocacy by Indigenous communities, the idea of Cultural Flows has slowly begun to enter the mainstream Australian political consciousness. Already, this has manifested in the inclusion of Indigenous engagement clauses in

water legislation and water sharing plans. An intergovernmental agreement for the creation of a joint Cultural Flows Commission would add a great deal of political and moral weight to the issue, highlighting its legitimacy (Painter 1998, p. 102).

Intergovernmental agreements have been described as a political act, rather than a legally binding contract (Betts 1964, p. 459; Dixon et al. 1962). Whilst this may seem to undermine the effectiveness of these means to federal-state cooperation as these agreements have no penalty for violation, this gives the parties to the agreements much greater flexibility in carrying out their commitments (Painter 1998, p. 102). Additionally, the joint resources invested by the parties provide an incentive for them not to opt out of the agreement (Painter 1998, p. 102). The greatest risk to intergovernmental agreements is neglect and default by the associated parties. Without consistent monitoring, such schemes can lose focus. This can be avoided by incorporating safeguards and contingencies into the enabling legislation and emphasising the symbolic, moral and political importance of in this instance Cultural Flows (Painter 1998, p. 103).

b) *Key parties to the agreement*

For intergovernmental agreement on Cultural Flows Commission to be effective, it must include as signatories:

1. First Nations, either corporately or as individual nations, as a body politic. Rather than treating them merely as special interest groups, First Nations should be engaged with as a political entity with a 'seat at the table' in water management (Hemming et al. 2017, p. 1).
2. Local governments, because this layer of government is often responsible for implementing and monitoring water management laws and related legislation in their local areas. They should be involved in the intergovernmental agreement and engage directly with the Commission once it is established.
3. Commonwealth, state and territory governments, because they are responsible for making the laws and policies that govern water management.

Ordinarily, local government and First Nations are rarely included as parties to such agreements. This must change to implement Cultural Flows effectively. All the key stakeholders should be represented in the intergovernmental agreement and the process should be characterised by collective decision-making and respect for Indigenous self-determination (Tsatsaros et al. 2018, p. 2). An intergovernmental approach to Cultural Flows is the most effective way to manage expectations and relationships between the parties.

³ Complimentary Applied Laws are recommended for the creation of a joint Cultural Flows Commission because this allows for national uniformity in laws which enable the creation of this commission, however this approach does not require the states to refer powers to the Commonwealth, and lose control of legislative capacity in water.

⁴ Mirror Legislation is recommended as this allows for a more flexible approach that can be tailored to the needs of Indigenous communities, different water resources, and different jurisdictions.

III. FUNCTIONS OF THE CULTURAL FLOWS COMMISSION

Once the intergovernmental agreement has been executed, the first step in establishing the Cultural Flows Commission (hereinafter 'the Commission') will be to define its mandate and powers. A charter detailing the Commission's role and responsibilities should be written. It is important that First Nations be allowed to lead the development of this charter, in collaboration with local, state, territory and federal governments. The charter developed by the Mackenzie River Basin Management Board in Canada is an example of a robust charter developed by incorporating Indigenous voices (Morris & de Loë 2016), which might serve as a model for the Commission's charter. In the Australian context, it is envisioned that the Commission will undertake work in four main areas:

1. Functioning as a mediator between First Nations and various levels of government in negotiations over water management, including investigating ways to create a First Nations Water Holder entity to purchase and manage water access entitlements on behalf of Indigenous communities
2. State/territory water legislation reviews and recommendations on law reform
3. Reviewing and advising on revisions to the NWI and the NTA
4. Research into how the Australian, and Indigenous legal system can be better mediated between by law, especially with respect to concepts of property and ownership.

The substantive reforms that would enable a proper 'meeting, shoulder to shoulder' between First Nations and the various levels of Australian government to reform property laws is not within the remit of this article. The first three areas of the Commissions' work will be explored in further detail below.

a) *A First Nations Water Holder*

This paper envisages a First Nations Water Holder as an independent agency or organisation that would act as a legal representative for First Nations in water matters; specifically, water entitlements. Although determining the exact form or structure of the First Nations Water Holder is not within the scope of this paper, it is proposed that this entity play a key role in Cultural Flows. In 2012 the First Peoples' Water Engagement Council was convened by the former National Water Commission, and it proposed that an Aboriginal Water Trustor Fund be developed to acquire and manage water rights, water reserves and a water fund for Indigenous peoples (Duncan & First Peoples Water Engagement Council 2016, p. 8; National Water Commission 2012; as per Macpherson 2019, p. 96). The National Water Commission "also stressed" the need for both an Indigenous water fund and water reserve

(National Water Commission 2012; as per Macpherson 2019, p. 94). This was recommended on the basis that, in water systems that are already fully allocated (meaning all available water entitlements have been purchased), creating such a fund would ensure Indigenous communities in these systems could still access water for Cultural Flows (Macpherson 2019, p. 96). A similar approach is advocated for in this paper, although it should be designed with great care. As Macpherson notes there is "still a great variance of opinion" both "within government and between and within Aboriginal communities" on the appropriateness of such a fund (Macpherson 2019, p. 97). If this fund were to be pursued, the Commission could assist in creating a First Nations Water Holder to represent Indigenous interests in the water market.

Indigenous land tenure is recognised and distributed unevenly across Australia. Even if water rights were to be recognised under the native title system, some Indigenous communities whose native title has been extinguished, or communities whose native title rights had not been recognised, would still be without water rights. This presents a problem of equity, because it would mean different rights for different communities.

A First Nations Water Holder could work to ensure a more even distribution of water entitlements. Further, the First Nations Water Holder's water fund could be used in circumstances where the capital outlay required to purchase water access entitlements on the open market in over allocated water systems would otherwise make Cultural Flows impossible. In systems that are not fully allocated, specific reserves of water could be set aside in planning processes to ensure that even if the water resources in those systems become fully commodified, a set amount will always remain available for Indigenous peoples to draw upon for Cultural Flows (Macpherson 2019, p. 95).

Nelson et al. (2018, p. 5) recommend a First Nations Water Holder as an immediate solution to Cultural Flows and a key part of ongoing reforms. Specifically, they reference the Chilean Indigenous Water Fund as an example of how a fully commodified water entitlements system such as ours, could include an entity dedicated to purchasing entitlements on behalf of Indigenous peoples (Nelson et al. 2018, p. 12). Comparative research has been undertaken on the Chilean model, which concluded that a similar approach would be the most immediately effective way of enabling Cultural Flows in Australia (Macpherson 2017).

Whilst the creation of a First Nations Water Holder is recommended in this paper, it is recognised that this is only one part the proposed solution. Such a fund would not 'create' Indigenous water rights, but merely purchase entitlements that could be used in the fulfilment of activities which constitute such rights. If this route is to be followed, the purchase of water

entitlements must only be undertaken based on direction from Indigenous communities, to ensure the process reflects their self-determination agenda.

b) *Setting a law reform agenda*

Introducing new substantive Indigenous water rights will require reform of state, territory and Commonwealth legislation. This could include new rights to use water for consumptive and commercial uses, instead of only the basic landholder rights/stock and domestic rights that are currently available. Alternatively, a scheme that allows water access entitlements to be acquired and held by a trust, in perpetuity, for the benefit of Indigenous communities could be pursued. The latter option could fall within the scope of the proposed First Nations Water Holder. To implement Cultural Flows for communities that would otherwise lose out, Indigenous water rights that are not tied to native title determinations still need to be pursued. This will allow for equal access to such water rights. The Commission could lead legislative reviews and make recommendations to all levels of government for law and policy reform initiatives to support Cultural Flows.

Key areas for reform

Some of the key areas the Commission could address are:

1. Indigenous Land Use Agreements (hereinafter 'ILUAs') were introduced under the Native Title Amendment Act 1998 (Cth). They were developed as an alternative to the native title claims determination process. ILUAs are long-term agreements that can be struck between First Nations, government and third parties (Neate 1999). ILUA' scan only be undone by agreement between the parties (National Native Title Tribunal 2014, p. 1). ILUAs have several limitations. They cannot recognise communal Indigenous water rights because they are still subject to the NTA (and its jurisprudence), which does not provide for such rights. ILUAs do not generally address the full range of Indigenous interests and often reflect the unequal balance of bargaining power between Indigenous peoples and other parties (Durette 2008, p. 35; Howard-Wagner & Maguire 2010, p. 82). Further, ILUAs are not a viable option for groups whose native title is deemed to be extinguished (Australian Human Rights Commission 2012). Reforming the rules relating to ILUAs could provide a way to recognise universal Indigenous water rights that do not depend on a successful native title claim. However, this would still require a reworking of legislation to widen the scope of interpretation for native title rights and interests as they relate to Indigenous water rights.
2. State and territory-based Indigenous land tenure legislation is also problematic. Generally, state and

territory governments have adopted a similar approach to ILUAs and sought to develop their own Indigenous land tenure legislation in response to the confrontational nature of native title determinations (Cowie 2018, p. 4). One of the advantages of the state and territory-based approach has been negotiated settlements, which have enabled cross-cultural learning. Arguably, successful cross-cultural negotiations have promoted co-management of resources to a limited degree (Son 2012). However, this approach cannot be relied upon as an effective legal basis for Cultural Flows. State and territory legislation has often been criticised as onerous and complex (Cooper & Jackson 2008). In addition, some state-based regimes merely mimic the federal native title system and in some cases, only provide rights that are the same as those already afforded to Indigenous peoples as ordinary members of the public (O'Bryan 2017, p. 593). Law reform at the state and territory level would support the broader changes needed to implement Cultural Flows. In particular, recognition of Indigenous water rights through state and territory water legislation, by altering the definitions of who 'owns' water and to what extent they may 'own' it, will play an important role.

3. The NTA is in dire need of reform. Under Section 109 of the Australian Constitution (hereinafter 'the Constitution'), Commonwealth laws prevail when there are inconsistencies between federal and state legislation. This means that state-based solutions to Cultural Flows cannot replace or override the NTA. The fact remains that the NTA is the primary vehicle through which Indigenous property rights have been recognised in Australia at the federal level (Durette 2008; Macpherson 2017, 2019; Marshall & Kirby 2017; O'Donnell et al. 2011). Therefore, reforming the NTA is essential for implementing Cultural Flows.
4. At an even higher level, there may also be scope for new treaties or constitutional reforms to support Cultural Flows. To the extent that such reforms are possible, recognition and protection of rights through treaties or constitutional amendment will provide legislative backing for Indigenous water and related rights. Although treaties and constitutional amendment may not be on the political agenda yet, they are worthy of mention here. A constitutionally enshrined Indigenous voice to parliament is already on the political agenda. The initiatives proposed in this paper are not contingent upon these other national level reforms. However, treaties and constitutional amendment would facilitate the implementation of Cultural Flows in Australia. Researchers Kildea and Williams have argued for a new constitutional settlement that is especially sensitive to environmental issues, and designed to

handle the current challenges in Australian water law (2010, p. 615). They have argued that there has always been potential for the Constitution to play a decisive role in the management of Australian waterways (Kildea & Williams 2010, p. 615); and hence a constitutional review to determine how the Constitution can promote and support a more cooperative approach to water management should be considered (Kildea & Williams 2010, p. 616). The Cultural Flows Commission could investigate this possibility further. The approach advocated in this paper seeks to circumvent the question of federal balance overwater management and legislative capabilities, instead opting for joint action by mutual consent. The continued tension between the states and the Commonwealth over constitutional remit, especially with respect to water resources, is reason enough for the Commission to avoid engaging in thorny constitutional matters too often (Kildea & Williams 2010). There is a danger that doing so could derail the Commission, if it oversteps its role. As such, the Commission should focus more on coordinating the national response and assisting in negotiating agreements wherever they are required.

5. Assisting as a mediator between First Nations and the various layers of government in relation to water entitlements, Indigenous water rights and their realisation, changes to state/territory water legislation, changes to the NWI and the NTA, changes to laws affecting the wider landscape through which water travels, and generally water governance in Australia.

The political reality of over allocated water resources in a drought-prone country like Australia means a pragmatic response is required to ensure Indigenous water rights do not become a partisan issue. The complexity of striking the balance between states, territories and Commonwealth powers, in addition to the volatile politics over water management in the Murray–Darling Basin, serve as a cautionary tale about why broad consensus is needed when pursuing water law reform in Australia (Twomey 2008).

Implementing reforms

Putting the necessary legal and institutional reforms into effect to enable the Commission will require joint action utilising what is termed ‘Complimentary Applied Laws’ (Wanna, Phillimore, Fenna, & Harwood 2009). This type of intergovernmental agreement is defined by one lead state implementing the legislation first, then all the other state, territory and Commonwealth governments doing the same. This approach has already been used successfully numerous times, one example being when the South Australian Parliament implemented the with the National Electricity Law, by passing the National Electricity (South Australia) Act 1996 (SA). The process allows governments to adopt a

uniform set of laws without granting exclusive legislative remit over water, to the Commonwealth. State-based Indigenous heritage legislation would also be relevant here. Linking the enabling legislation for the Commission to heritage legislation would help entrench Indigenous water rights in the broader legislative framework.

As Nelson et al. (2018) have argued, a single uniform legal response to Cultural Flows cannot be expected to work for all Indigenous communities. A nuanced approach to implementation is necessary, and as Marshall & Kirby argue, reform must be led by Indigenous communities (2017). While the approach proposed in this paper focuses on creating a single institution, the Cultural Flows Commission, the legislation developed to recognise Indigenous water rights, and to manage and govern water must be adapted to each jurisdiction. A balance must be struck between a unified national focus and each jurisdiction and each Indigenous community’s specific context (Marshall & Kirby 2017, p. 162; Nelson et al. 2018) Nelson et al. 2018). Further, it is imperative that considerable consultation work which is led by First Nations, be undertaken prior to implementation of Indigenous water rights’ affirming legislation. This will ensure the reforms properly meet the needs of Indigenous communities.

c) Revising the National Water Initiative

The product of an intergovernmental agreement made in 2004, the NWI was one of the first national attempts to incorporate Indigenous values and customs into water planning and to remedy some of the inequities experienced by Indigenous communities in relation to water rights. However, the NWI includes only limited duties to consult with Indigenous peoples, which have been criticised for being discretionary and non compulsory (Macpherson 2017; Marshall & Kirby 2017, p. 84). Firstly, the languages adopted in the NWI calls for consultation with Indigenous communities ‘wherever possible’ rather than consultation ‘always’, and ‘each and every time’ (Durette 2008, p. 35). In effect, this undermines the consultation requirement, making it more akin to a guideline than a requirement, one that may be readily ignored (O’Donnell et al. 2011). Other aspects of Indigenous engagement in the NWI are similarly discretionary, which means there is no enforceable power to include Indigenous interests in NWI implementation plans (Marshall & Kirby 2017, p. 84). Secondly, the NWI only accounts for Indigenous interests formally recognised under the native title system (Marshall & Kirby 2017, p. 84). Groups without formal native title are excluded completely.

Prior to the NWI, riparian water rights (imported into Australia’s legal system from the Imperial British common law) and the rights to use water for agriculture and industry were directly linked to land ownership

(Macpherson 2017, p. 6). The NWI introduced the 'unbundling' of property rights over land from water rights, making them separate legal and commercial interests in the Murray-Darling Basin. This meant that native title claimants' land rights, if at all recognised, no longer included rights to the water resources on their land (Macpherson 2017, pp. 4_5).

One of the main aims of the NWI was reforming water and property legislation to encourage more efficient use of water through increased competition on an open market, the idea being that water will flow to its most valuable usage (Tietenberg & Lewis 2016), this being due to water markets "creat[ing market] incentives" for water to be traded as a commodity (Murray-Darling Basin Authority 2019, p. 1). The establishment of 'water markets' required the division of water rights from land holdings. This has complicated Indigenous access to water resources (Macpherson 2017, p. 6). Whereas previously, water entitlements were incidental to land tenure, the changes introduced by the NWI mean that native title claims and other Indigenous land tenure legislation do not provide access to water entitlements (Macpherson 2017, p. 6). Instead, water access entitlements must be purchased on the open water markets. By creating trade able water rights decoupled from land title, the NWI has added to, rather than remedied, the exclusion of Indigenous peoples from the water economy (Jackson et al. 2019, p. 3).

The NWI divided water usage into 'consumptive uses' requiring water access entitlements (which includes irrigation, industry, urban and 'stock and domestic' uses, although the latter may not require an entitlement) and 'environmental and other public benefit' uses (Macpherson 2017, p. 6). The basic landholder rights available under native title fall within the same category as stock and domestic uses and usually do not require a formal water access entitlement (Macpherson 2017, p. 6). The NWI's categorisation of water uses and separation of water from land rights is antithetical to Cultural Flows, which by their very nature, require Indigenous access to large volumes of water and the freedom to use water in many different ways to 'maintain the spiritual, cultural, environmental, social and healthy livelihoods of Indigenous peoples of Australia' (Murray and Lower Darling Rivers Indigenous Nations 2007, p. 2). It is envisaged that the Cultural Flows Commission would play a key role in negotiating changes to the NWI that would support Indigenous self-determination and wellbeing.

IV. CONCLUSION

This paper has demonstrated that existing legislation is ill equipped to truly engage with Indigenous water rights, much less the complexity of Cultural Flows. Wholesale reform of water legislation is required, but also reform of other legislative regimes that relate to the

land through which water travels, and water governance in Australia. It is proposed that an intergovernmental agreement between First Nations and all levels of government be entered into with the aim of creating a joint Cultural Flows Commission. This intergovernmental approach has a long history in Australia as an effective means to coordinate a national response. From there, the Commission would take the lead in engaging First Nations as a body politic, rather than merely as special interest groups, and inviting all levels of government to work collaboratively on the legal and policy reforms necessary to implement Cultural Flows. New human rights charters, treaties, constitutional amendment and an Indigenous voice to parliament are not essential for the approach recommended in this paper, but they would help give substances to Cultural Flows.

The United Nations Permanent Forum on Indigenous Issues has raised concerns about other countries' ineffective handling of contentious water rights issues (Marshall & Kirby 2017). Australia is not immune to these same problems. Indeed, it is incumbent upon Australia's governments to address Indigenous water rights concerns to ensure compliance with the United Nations Declaration on the Rights of Indigenous Peoples (Marshall & Kirby 2017). Australia's obligations under international law should provide additional incentives for implementing Cultural Flows and may even be used to inform federal, state and territory legal reforms. While there are other mechanisms available that can assist in moving the Cultural Flows agenda forwards, this paper takes the view that as a strong, independent national body with a specific remit in this area, the Cultural Flows Commission would be best placed to ensure all stakeholders are afforded equal respect and influence in decision-making. Specifically, it is envisaged that the Commission will function as a mediator between First Nations and government to facilitate agreements for managing water resources; contribute to the prospective establishment of a First Nations Water Holder (that will purchase and manage Indigenous water access entitlements); undertake legislative reviews and make recommendations for reforming state, territory and Commonwealth water legislation, the NTA and the NWI; and conduct research into how Indigenous perspectives (and concepts of property) can mediate between the Australian and Indigenous legal systems.

Implementing Cultural Flows requires a new national framework, one that places First Nations at the centre of water management in Australia (Marshall & Kirby 2017; Nelson et al. 2018). Although various recommendations have been offered in this paper, the exact routes by which this will be achieved cannot be stated with certainty at this stage. Questions about matters such as the First Nations Water Holder, the mediation functions of the Commission, how new Indigenous water rights should be constructed or how

the existing native title system might be reformed should be answered by Indigenous communities, in collaboration with the other stakeholders. It is envisaged that First Nations will play a key role in leading the Commission as well as in law reform and negotiating new water sharing agreements and governance structures. Recognising and protecting Indigenous waters rights will help to empower Indigenous peoples, both economically and culturally. Implementing Cultural Flows will contribute to improved health and socioeconomic outcomes for Indigenous communities. It will also benefit the environment and Australian society at large (Weir 2010, p. 138). An inter governmental agreement on Cultural Flows and the establishment of a Cultural Flows Commission will provide Australia with a unique opportunity to demonstrate bipartisan commitment to 'closing the gap' (Australian Human Rights Commission 2019; Australian Indigenous Health Info Net 2016).

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INTRODUCTION



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Associates of FERC/AERC are scientists and researchers from around the world are working on projects/researches that have huge potentials. Members support Global Journals' mission to advance technology for humanity and the profession.

FERC

FELLOW OF ENGINEERING RESEARCH COUNCIL

FELLOW OF ENGINEERING RESEARCH COUNCIL is the most prestigious membership of Global Journals. It is an award and membership granted to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Fellows are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Fellow Members.



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Exclusive

Reputation



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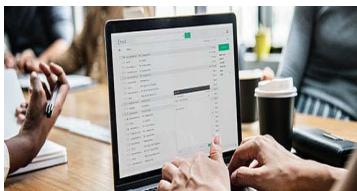
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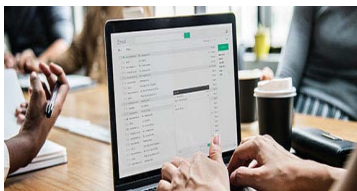
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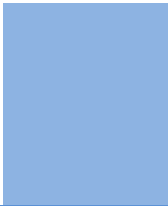
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Acknowledgments

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The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.



Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

- a) A title which should be relevant to the theme of the paper.
- b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
- c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
- d) An introduction, giving fundamental background objectives.
- e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
- f) Results which should be presented concisely by well-designed tables and figures.
- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

- i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
- j) There should be brief acknowledgments.
- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.



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It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

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Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

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The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

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For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

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2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

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6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

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10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.



21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.



Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.



Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

THE ADMINISTRATION RULES

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BY GLOBAL JOURNALS

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Topics	Grades		
	A-B	C-D	E-F
<i>Abstract</i>	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
<i>Introduction</i>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<i>Methods and Procedures</i>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<i>Result</i>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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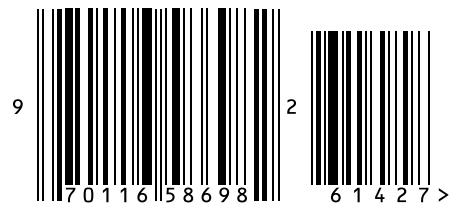


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