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Some sources of complexity in programs/projects
by Alan Stretton
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INTRODUCTION

I recently published an article in this journal on the nature of programs (Stretton 2017a), in which I pointed out that, contrary to the way they are so often depicted in the literature, programs are not necessarily large or complex.

However, in the second edition of the *Gower Handbook of Programme Management* (Lock & Wagner 2016) most of the contributions were concerned with large complex programs/projects, and this is certainly an area of major concern in the program/project literature at large. Effective management of large complex programs/projects is undoubtedly very difficult, and this topic fully deserves the increased attention it appears to be attracting in the literature.

I have had little direct personal experience on large complex projects, and have therefore been somewhat hesitant about addressing this topic. However, Bob Prieto's articles in this journal on large complex projects, and his book on a *Theory of Management of Large Complex Projects* (Prieto 2015) particularly attracted my attention. Amongst other things, I noted that he listed no less than 66 sources of complexity in large engineering and construction programs.

The new edition of the *Gower Handbook* also has substantial material on program/ project complexity, and its sources. So, I had the notion of comparing contributions from these two publications, plus some others, to try and get some alignment of various sources of complexity, and perhaps a combined checklist of sources of complexity. That is what this article attempts to do.

In all, I found eight relatively recent contributions on such sources. I discuss each of these in turn, and then map seven of them onto the most detailed listing of the eight, which is that of Prieto 2015. This is essentially an exploratory article, so we will see what emerges from this quite extensive mapping exercise.

1. SOURCES OF COMPLEXITY ON GIGA-PROGRAMS – Prieto 2015

By far the largest list of sources of complexity on programs/projects that I know of comes from Prieto 2015, who offers a list of sixty six such sources in his Table 2-2. It should be emphasised that Prieto was particularly concerned with what he calls gigaprograms, by which he means programs with constructed values in excess of $10 billion (US), in the engineering and construction sector. In his words (p.37),

> I have chosen this subset of projects since I believe that many of the particular challenges we see at this scale and level of complexity exist more broadly in large complex projects but are perhaps not as easily seen.

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Prieto goes on to point out that, with gigaprograms, new sources of complexity emerge that are not typically encountered in what he calls traditional scale programs. However, I have chosen to include all Prieto's sources (which are shown later in Figures 9, 10, 11 & 12), because they form a very detailed, inclusive, and hopefully useful, checklist of sources of complexity in programs/ projects.

Figure 1 shows the seven main categories used by Prieto, and the number of detailed sources of complexity in each category. (I have changed the order from Prieto's Table 2-2).

We will now look at seven other contributions to listing sources of complexity in the program/project context. I then propose to map each of these seven against Prieto's categories and his detailed sources of complexity. Ideally, this would be best shown on a large spread-sheet. However, as this cannot be done in this journal, I have divided the mappings into three groups, as will be seen later.

1. PRIETO 2015, Table 2-2	
SOURCES OF COMPLEXITY Main categories, and number of sources in each category	
ENVIRONMENTAL	**[4]**
POLITICAL	**[6]**
STRATEGIC BUSINESS OUTCOMES (SBOs)	**[8]**
TECHNOLOGICIAL	**[8]**
PROJECT PORTFOLIO	**[7]**
PROGRAM EXECUTION	**[19]**
ORGANIZATION	**[14]**

Figure 1: Prieto's main categories of sources

2. FOUR TYPES OF PROJECT COMPLEXITY – Hayes 2016: Zolin et al 2009

Hayes 2016 say that in their book *Tools for Complex Projects,* Remington & Pollack 2007 have suggested four types of complexity as useful categories. He evidently reproduces these from Zolin et al 2009. I have shown how I have summarised the following descriptors in Figure 2. Their categories are as follows (my ordering):

- **Temporal complexity:** Refers to volatility over the duration of the project, where project durations are extended and where the environment (market, technical, political or regulatory) is in a stated of flux.

- **Directional complexity:** Found in projects where the goals or goal-paths are not understood at all levels of the project hierarchy …..

  [I have split this source of complexity into two elements, to facilitate mapping onto Prieto's detailed classifications, as will be seen later]

- **Technical complexity:** Found in projects with design characteristics or technical aspect that are unknown or untried ….

- **Structural complexity:** Stems from non-linear, emergent behaviour which can occur from interactions between many interconnecting tasks ….

We continue with another contribution from Hayes 2016.

2.Hayes 2016: Zolin et al 2009
• **TEMPORAL complexity:** Volatility over extended project durations, where the environment is in a state of flux
• **DIRECTIONAL complexity:** 1) Where project goals are not understood or agreed upon at all levels 2) Where project goal-paths are not understood or agreed upon at all levels
• **TECHNICAL complexity:** Found in projects with unknown or untried design characteristics or technical aspects
• **STRUCTURAL complexity:** Stems from potential non-linear, emergent behaviour which can occur from interactions between many interconnected tasks

Figure 2. Hayes 2016: Zolin et al 2009

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3. ASSESSING COMPLEXITY USING THE HELMSMAN SCALE – Hayes 2016

Hayes 2016 discusses the assessment of complexity in programs, which includes use of the Helmsman Complexity Scale. Hayes reports that projects are evaluated against criteria in five areas:

- **Context complexity** – which looks at the complexity of the leadership and political environment the project is facing.

  [I have split this into two in Figure 3 to facilitate mapping against appropriate categories in Prieto 2015]

- **People complexity** – evaluates how deep the sociological change will be for the recipients of the project.

- **Ambiguity** – which is measured across two areas, namely approach uncertainty and design uncertainty.

  [I have also split this into two to facilitate mapping]

- **Technical challenge** – Technical complexity is measured by examining the definition, history of development, and number of core subsystems expected in the final solution as well as previous experience in subsystem integration.

- **Project management challenge** – the areas being evaluated include contract complexity, risk sharing, schedule and project structure, supplier complexity and external project interdependencies.

3. Hayes 2016: Helmsman

- **CONTEXT complexity**
1) The complexity of the project's political environment
2) The complexity of the project's leadership

- **PEOPLE complexity**
How deep the change will be for the recipients of the project

- **AMBIGUITY:**
Measured across two key areas, namely
1) design uncertainties, &
2) approach uncertainties

- **TECHNICAL challenge**
Measured by examining the definition, history of development, and number of core sub- systems expected in the final solution

- **PROJECT MGT. challenge**
The areas being evaluated include contract complexity, risk sharing, schedule and project structure, supplier complexity and external project interdependencies

Figure 3. Hayes 2016: Helmsman

4. CRANFIELD'S TWO-TYPE CATEGORISATION – Cooke-Davies 2016

Cooke-Davies 2016 says that a team at Cranfield University found that the preponderance of problems found in complex programs were caused by what they called 'socio-political complexity' or by 'emergent' complexity' (Maylor et al 2013). Cooke-Davies describes these thus:

- ***Socio-political complexity*** refers not only to the behavioural challenge in engaging people in changes, but also to the cultural and political dynamics within the program team and in the wider stakeholder communities.

  [I have split this into three sections in Figure 4, to facilitate later mapping against Prieto 2015]

- ***Emergent complexity*** refers to the inherent uncertainty that arises from the intermixing of novel technological, human and

4. Cooke-Davies: Cranfield

- **SOCIO-POLITICAL complexity**
1) Cultural & political dynamics in the wider stakeholder communities
2) The behavioural challenges of engaging people in changes
3) The cultural and political dynamics within the programme team

- **EMERGENT complexity:**
Arising from intermixing novel technological, human and social arrangements that give rise to unforseen and unforeseeable consequences

Figure 4. Cooke-Davies: Cranfield University

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social arrangement which give rise to unforeseen and unforeseeable consequences.

5. INSTITUTIONAL AND INDIVIDUAL COMPLEXITY – Heywood et al 2007

Cooke-Davies 2016 says that Heywood et al 2007 distinguish between two types of complexity, described by them as 'institutional complexity' and 'individual complexity', which he describes as follows.

* *Institutional complexity* arises out of the strategic choices made by the organization, the external context within which the organization operates, and the management and operating systems that it employs to provide its goods or services.

  [I have split institutional complexity into three sections, to better align them with the Prieto categories]

* *Individual complexity* refers to the ways by which individuals operating within the organization experience and deal with complexity.

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5. Cooke-Davies: Heywood
··

* **INSTITUTIONAL complexity**:
1) The external context in which the organization operates
2) The strategic choices made by the organisation
3) The management and operating systems it employs to supply its products or services

* **INDIVIDUAL complexity:**
The ways by which individuals operating within the organization experience /deal with complexity.

Figure 5. Cooke-Davies: Heywood et al 2007

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6. GAPPS (Global Alliance for Project Performance Standards) 2007

GAPPS was concerned with project complexity, and developed an approach to categorising projects based on their management complexity. They identified the following seven factors that affect the management complexity of a project (my ordering and numbering)

1) *Stability of the overall project context.* The project context includes the project life cycle, the degree to which the applicable methods and approaches are known, and the wider socioeconomic environment. …

2) *Magnitude of legal, social, or environmental implications from performing the project.* This factor addresses the potential *external* impact of the project. ….

3) *Overall expected financial impact (positive or negative) on the project's stakeholders.* This factor accounts for one aspect of the traditional measure of "size", but does so in relative terms. …

4) *Stakeholder cohesion regarding the characteristics of the product of the project.* When all or most stakeholders are in agreement about the characteristics of the product of the project, they tend to be in agreement about the expected outcomes as well. When they are not in agreement, or the benefits of a product with a particular set of characteristics are unknown or uncertain, the project management challenge is increased.

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6. GAPPS 2007
···

1) Stability of the overall project context

2) Magnitude of legal, social, or environmental implications

3) Overall financial impact on the project's stakeholders

4) Stakeholder cohesion re product characteristics

5) Strategic importance to the organization

6) Number of distinct disciplines, methods or approaches involved

7) Number and variety of interfaces between project and other organizational entities

Figure 6. GAPPS 2007

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5) ***Strategic importance of the project to the organisation or organisations involved.*** This factor addresses yet another aspect of "size", and again deals with it in relative rather than absolute terms. Whilst every project should be aligned with the organisation's strategic direction, not every project can be of equal importance to the organisation or organisations involved.

6) ***Number of distinct disciplines, methods or approaches involved in performing the project.*** Most projects involve more than one management or technical discipline; some projects involve a large number of different disciplines. … Since each discipline tends to approach its part of the project in a different way, more disciplines mean a project that is relatively more difficult to manage.

7) ***Number and variety of interfaces between the project and other organisational entities.*** In the same way that a large number of different disciplines on a project can create a management challenge, a large number of different organisations can as well.

7. FACTORS DRIVING PROGRAM COMPLEXITY – Parth 2016

Parth 2016 says that program complexity is driven by the following seven factors
(my order of presentation)

1) ***Regulatory complexity –*** particularly when governments manipulate regulatory approvals in order to gain more concessions or money from the owners.

2) ***Dynamic complexity –*** changes in multiple areas during the lifetime of the project including changes in the economic environment, political environment, regulatory environment, and technology.

3) ***Financial complexity –*** projects of this size are rarely financed by a single entity (exceptions are some government-funded infrastructure projects. in the vast majority they create a financial consortium to share the risk and financers have different motivations and timescales than the owners or contractors do.

4) ***Time scale –*** very long projects are subject to larger swings in the overall economic environment.

5) ***Technical complexity –*** How difficult and challenging the technology is as well as how rapidly the technology is changing.

6) ***Project team –*** number of contractors working on the projects from multiple countries and cultures.

7) ***Client/customer –*** significant complexity can be added by the owners by changing scope after the work has started.

7. Parth 2016
....
1) **Regulatory complexity**

2) **Dynamic complexity:**
Changes in economic, political, regulatory, technological environments

3) **Financial complexity:**
Re providers of finance

4) **Time scale:**
Very long projects are subject to large swings

5) **Technical complexity:**
Technological difficulty, challenges, rate of change

6) **Project team:**
Number of contractors

7) **Client/customer:**
Causing scope changes

Figure 7. Parth 2016

We now move on to look at a typology of project complexity by Geraldi et al 2011.

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8. A TYPOLOGY OF PROJECT COMPLEXITY – Geraldi et al 2011

Shenhar et al 2016 have given the following exposition of the five dimensions of a project's complexity identified by Geraldi et al 2011.

1) **Socio-political complexity:** This kind of complexity relates to the problems involved when managing stakeholders, such as lack of commitment, or problematic relationships between stakeholders, as well as those related to the team. …. Overall, this factor emerges as a combination of the political aspects and emotional aspects involved in projects.

2) **Uncertainty:** Uncertainty represents the gaps between the amount of information required to make a decision and what is available. Uncertainty has an intrinsic relationship with risks, but as the literature suggests, there may be different types of uncertainty, such as uncertainty of goals and uncertainty of methods (Turner & Cochrane 1993).

3) **Structural complexity:** Structural complexity relates to a large number of distinct and interdependent elements. It is impacted by size, variety, and interdependence of the elements.

4) **Dynamics:** Dynamics refers to changes in factors such as goals or specifications. When changes are not communicated or assimilated by the team, such changes may lead to high levels of disorder, rework, or inefficiency. …

5) **Pace:** Pace relates to the temporal aspects of a project. It represents the urgency and criticality of time goals. Pace essentially refers to the rate or speed at which products should be delivered.

8. Geraldi et al 2011

1) **Socio-political complexity:**
Notably managing stakeholders

2) **Uncertainties:**
Re goals, and/or methods

3) **Structural complexity:**
Number of distinct & inter-dependent elements

4) **Dynamics:**
Changes in goals or spec's.

5) **Pace:**
Urgency /criticality of time goals

Figure 8. Geraldi et al

MAPPING FIGURES 2 TO 8 ON TO PRIETO'S SOURCES OF COMPLEXITY (AN AUGMENTED FIGURE 1)

In the following three figures we map the latter seven listings of sources of complexity (i.e. Figures 2 to 8) against Prieto's listings, as headlined in Figure 1. We will now be including all sixty six of Prieto's detailed sources of complexity in these mapping figures. However, in the next three figures I have found it expedient to abbreviate some of the descriptors of Prieto's sources, mainly for space and matching considerations. The full descriptors used by Prieto appear in Figure 12.

As noted earlier, in lieu of a substantial spread-sheet we will split Prieto's listings into three major sections, and align the components of the other seven categorisations with these as best we can.

Whilst many, indeed most, of these components will match one or more of Prieto's many sources of complexity, there are some which do not, and we will be discussing the latter in more detail in the following.

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MAPPING TO PRIETO'S POLITICAL, ENVIRONMENTAL AND PART SBO CATEGORIES AND SOURCES OF COMPLEXITY

The mapping

Mapping the other seven contributors to the first sector of Prieto's listings has turned out to be somewhat of a challenge in compressing materials to get all contributions on to one sheet. I have omitted materials from Hayes 2016: Zolin et al 2009, as they do not map onto this section of Prieto. All the remaining relevant materials are here. It can be seen that many of the "other" sources correspond with Prieto's listings, but one particular group of sources of complexity does not, which has prompted a significant suggested addition to the Prieto categories, as discussed below.

1. Prieto 2015: Table 2-2	Hayes: Helmsman	5.Cooke-D: Heywood	6. GAPPS 2007	7.Parth 2016	8. Geraldi et al
ENVIRONMENTAL [4] Extent of regulatory processes Number of significant issues Effective footprint; Duration of impacts *[SOCIO]*-**POLITICAL** [6] Degree of political sensitivity; Political stability; Role in power struggles Sustainability of political will Supply chain role in internat'l relat'ns Extent of capacity building, feedback *[STAKEHOLDERS & CUSTOMERS]*	• **CONTEXT complexity** 1) The complexity of the project's political environment • **PEOPLE complexity:** *How deep the change will be for the recipients of the project*	• **INSTITUTIONAL complexity:** 1) The external context in which the organization operates **4.Cooke-D: Cranfield** • **SOCIO-POLITICAL complexity** 1) *Cultural and political dynamics in the wider stakeholder communities*	1) Stability of overall project context 2) Magnitude of legal, social, or environmental implications 3) *Overall financial impact on the project's stakeholders* 4) *Stakeholder cohesion re product characteristics*	1) **Regulatory complexity** 2) **Dynamic complexity:** Changes in economic, political, etc environment 3) *Financial complexity: re providers of finance*	1) *Socio-political complexity: notably managing stakeholders*
STRATEGIC BUSINESS OUTCOMES (SBOs) [8] Conflicting SBOs Scope/reach of defined outcomes Owner complexity [JV; alliance; etc]		**5.Cooke-D: Heywood** • **INSTITUTIONAL complexity** 2) The strategic choices made by the organisation	5) Strategic importance to the organization		

Figure 9. Mapping on to the first sections of Prieto's listings of sources of complexity

Adding a *Stakeholder and Customer* category

The most obvious thing to emerge from this mapping is that five of the six "other" categorisations specifically include sources of complexity relating to stakeholders and/or customers. These are underlined, bolded and italicised in Figure 9.

GAPPS 2007 has two sources that specifically mention stakeholders, as do Cooke-Davies:Cranfield and Geraldi et al. Parth 2016 specifically mentions a particular type of stakeholder, namely providers of finance. Hayes:Helmsman is concerned with recipients of the project, which I take to mean customers in particular, and probably other stakeholders as well.

Since Prieto does not have a specific listing for *stakeholders and customers* as sources of complexity, I have added this as an additional specific category.

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Under this heading, additional sources of complexity from five "other" authors are:

- How deep the change will be for the recipients of the project
- Cultural and political dynamics in the wider stakeholder community
- Overall financial impact on the project's stakeholders
- Stakeholder cohesion re product characteristics
- Financial complexity: re providers of finance
- Socio-political complexity: notably managing stakeholders

Broadening the *Political* category to *Socio-Political*

Both Cooke-Davies: Cranfield and Geraldi et al specifically use the heading *Socio-Political*, and I propose to adopt this broader heading.

MAPPING TO PRIETO'S SBO, TECHNOLOGICAL AND PROJECT PORTFOLIO CATEGORIES AND SOURCES OF COMPLEXITY

The mapping

This is a little complicated, as I have split Prieto's *SBO* category by nominating two subsection titles (*Temporal complexities* and *Goals uncertainties*), and have added *Methods uncertainties* to his *Technological* category, as further discussed below.

1. Prieto 2015: Table 2-2 (cont'd)	2.Hayes 2016: Zolin et al 2009	3. Hayes: Helmsman	7. Parth 2016	8. Geraldi et al
STRATEGIC BUSINESS OUTCOMES (SBO) [8] Conflicting SBOs Scope/reach of defined outcomes Owner complexity [JV; alliance; etc]				
[TEMPORAL complexities] SBO migration over time Competitive landscape changes Market migration	• **TEMPORAL** complexity: Volatility over extended project durations, where the environment is in a state of flux		4) **Time scale:** Very long projects are subject to large swings	
[GOALS uncertainties] Ambiguity, visibility, poor alignment Economic susceptibility (local, global)	• **DIRECTIONAL** complexity: 1) Where project **goals** are not understood or agreed upon at all levels	• **AMBIGUITY:** Measured across two key areas, namely 1) design uncertainties, &		2) **Uncertainties:** re **goals**, and/or **methods**
TECHNOLOGICAL *[AND METHODS uncertainties]* [8] New processes; New tools; IT complexity Tech design basis not fixed Inadequate prototyping, planning etc Specialised materials or skills Limited number of suppliers Extent of systems integration	2) Where project goal-paths are not understood or agreed upon at all levels • **TECHNICAL** complexity: Found in projects with unknown or untried design characteristics or technical aspects	2) approach uncertainties **TECHNICAL challenge** Measured by examining the definition, history of development, and number of core sub-systems expected in the final solution	5) **Technical complexity:** Technological difficulty, challenges, rate of change	
PROJECT PORTFOLIO [7] *[STRUCTURAL complexities]* Number of projects Precedences & interdependencies Uncertainties of assumptions, data Sophistication of modelling, analysis Assumption migration; No. of constraints Definition of "white space" *Emergent sources of complexities*	• **STRUCTURAL** complexity: Stems from potential non-linear, *emergent* behaviour which can occur from interactions between many interconnected tasks	**4. Cooke-D: Cranfield** *EMERGENT complexity:* Arising from intermixing novel technological, human and social arrangements that give rise to unforseen and unforeseeable consequences	6) **Project team:** No. of contractors **6. GAPPS 2007** 6) Number of distinct disciplines, methods or approaches involved	3) **Structural complexity:** No. of distinct & inter-dependent elements

Figure 10: Mapping on to the middle sections of Prieto's listings of sources of complexity

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Adding a *Temporal complexities* sub-heading in the *SBO* category

Both Zolin et al and Parth have described this source of complexity quite well in general terms, and they align well with Prieto's three more detailed sources, which I have put under this heading. This appears to be a natural subdivision.

Goals uncertainties and methods uncertainties:
   Adding a *Goal uncertainties* sub-heading in the *SBO* category, and
   Adding *and Methods uncertainties* to the Technological category heading

As I have interpreted them, each of Zolin et al, Hayes:Helmsman, and Geraldi et al have identified sources of complexity associated with uncertainties in both project *goals* and *methods* of achieving them. Geraldi et al do this explicitly, and Zolin et al nearly so, if I am correct in interpreting their *goal-paths* as another way of saying *methods.* I have associated the Hayes:Helmsman's *design uncertainties* with uncertainties about *goals,* and their uncertainties about *approach* with *methods.*

In Prieto's listings, the last two specific sources in his SBO category appear to me to be mainly associated with project *goals uncertainties*, so I am proposing to use this sub-heading to identify the two.

Prieto does not have a specific entry for methods uncertainties. However, the majority of the sources of complexity listed under his Technological heading are methods-related, so I have proposed adding *and Methods uncertainties* to this heading, to accommodate the methods components of the relevant contributions from Zolin et al, Hayes:Helmsman, and Geraldi et al, as shown in Figure 10.

As can be seen, three "other" contributors also include technological sources of complexity in much the same way as Prieto, but without the detail of the latter.

Project portfolio category – adding *[Structural complexities]* to this heading

It appears to me that Prieto's *Project Portfolio* category would be more appropriately entitled *Structural complexity*, which is the heading used by both Zolin et al and Geraldi et al. So I have added this, in square brackets, to Figure 10.

Adding *emergent* sources of complexities

Cooke-Davies: Cranfield specifically introduces *emergent complexity*, whilst Zolin et al include *emergent behaviour* in their description of structural complexities. I do not see any such entries amongst Prieto's sources, so propose adding *Emergent sources of complexity* to his list, and indicated in square brackets in Figure 10.

We now move on to the last of the three maps.

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MAPPING TO PRIETO'S PROGRAM EXECUTION AND ORGANIZATIONAL CATEGORIES AND SOURCES OF COMPLEXITY

The mapping

This is relatively straight-forward. Zolin et al 2009 do not have any items which map against this group of Prieto's sources of complexity. A number of new sources of complexity emerge which could be added to Prieto's already extensive listing. I have added *project* to the *Program/project execution* heading to make it more inclusive.

1. Prieto 2015: Table 2-2 (cont'd)	Hayes: Helmsman	5.Cooke-D: Heywood	6. GAPPS 2007	7.Parth 2016	Geraldi et al
PROGRAM/*PROJECT* EXECUTION [19] Cyclomatic complexity Structural complexity of plan, WBS,. Shared constraints; Coupling degree No. of changes; Supply chain resiliency Depth of labour pool; Predictability Physical complexity of projects Special equip't availability, lead times Permit & regulatory complexity, timeliness Logistical congestion & choke points Flexibility of sequencing Financial constraints; Regulatory constraints Integration of mgt tools & systems Shallow risk mgt; Extent of feedback Distance of projects etc from operations	**PROJECT MGT. Challenge:** The areas being evaluated include *contract complexity*, risk sharing, schedule and project structure, supplier complexity and external project interdependencies	• **INSTITUTIONAL complexity**: 3) *The management and operating systems* it employs to supply its products or services		7) **Client/ customer**: Causing scope changes	4) **Dynamics:** Changes in goals or spec's. 5) *Pace: urgency/ criticality of time goals*
ORGANIZATIONAL [& PEOPLE] [14] Inadequate shared understanding PM " clarity of roles/ responsibilities Resistance to change Value destroying processes, procedures Lack of sense of urgency Stress level; team fatigue Silos re sharing knowledge etc Cultural issues No. of locations Distance of program from business Inadequate workshare systems etc Duplication of efforts (Owner/PMC) Duplication of efforts (PMC/suppliers) Risk aversion vs. risk management	• **CONTEXT complexity:** 2) The *complexity of the project's leadership*	• **INDIVIDUAL complexity:** The ways by which *individuals operating within the organization experience /deal with complexity.* **4.Cooke-D: Cranfield** 2) The behavioural challenges of engaging people in changes 3) *The cultural and political dynamics within the programme team*	7) Number and variety of *interfaces between project and other organizational entities*		

Figure 11: Mapping on to the bottom sections of Prieto's listings of sources of complexity

Program Execution – additional sources of complexity

- ***Contract complexity:*** There are several sources of complexity nominated by Hayes:Helmsman under the heading *Project Management Challenge*. I have chosen *contract complexity*, because it does not appear to be covered by Prieto. The other sources nominated above do appear to be covered by Prieto, albeit in an implicit way (although some may well see this as arguable).

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- ***Complexity re the management and operating systems:*** Hayes:Helmsman have nominated the *management and operating systems* the organization employs to provide its products or services as a source of complexity. This seems to be a reasonable candidate to be added to Prieto's listings.
- ***Pace: urgency and criticality of time goals***, proposed by Geraldi et al, appears to be another candidate for inclusion as an additional source of complexity.

Organizational – additional sources of complexity

- ***Interfaces between project and other organizational entities:*** This source of complexity, proposed by GAPPS 2007, does not appear to be covered by Prieto, so will be added to his listings in the Organizational category.

Organizational category – adding "*and People*" to this heading

The three other candidates which have been mapped against Prieto's *Organisational* category are each strongly people-related, albeit in somewhat different ways. Prieto does not have a specific source of complexity that is people-related, so I am augmenting this category by describing it as *Organizational and People.*

Organizational and People – additional sources of complexity

- ***Complexity of the project's leadership***
- ***The cultural and political dynamics within the program team***
- ***Individual complexity: the ways by which individuals operating in the organization experience/deal with complexity***

These three sources of complexity, from three different author groups, are all people-related, moving from the manager/ leader, through project team dynamics, to individual themselves. These would appear to be worthwhile additions to the listings under this heading.

A BASIC CHECKLIST OF SOURCES OF COMPLEXITY

Prieto's seven categories and his sixty six detailed sources of complexity have formed the backbone of these mappings. The sources of complexity from the seven "other" author groups have been mapped against Prieto. Many of the "other" types of complexity have aligned well with Prieto. Some others did not initially align so well, until I made some additions and amendments to some of Prieto's original categories to broaden their coverage. This facilitated alignment of many more of the "other" categories with those of Prieto. Finally, we found fourteen sources of complexity from the "other" authors which do not appear to be specifically covered by Prieto.

Combining all the above, we have a basic checklist of sources of complexity as shown in Figure 12. The vast majority of these sources comes from Prieto (now in full detail), and these are presented in normal typeface. The additional sources derived from the other seven author groups are shown in *italicised typeface.*

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ENVIRONMENTAL
- Extent of regulatory processes
- Number of significant issues
- Effective footprint
- Duration of impacts

SOCIO-**POLITICAL**
- Degree of political sensitivity (project or key supply locations)
- Political stability (no. of relevant political players; no. of election cycles or other anticipated changes of government)
- Role in power struggles
- Sustainability of political will
- Role of supply chain role in international relations (enabler or held hostage)
- Extent of capacity building and feedback role

STAKEHOLDERS & CUSTOMERS
- *How deep the change will be for the recipients of the project*
- *Cultural and political dynamics in the wider stakeholder community*
- *Overall financial impact on the project's stakeholders*
- *Stakeholder cohesion re product characteristics*
- *Financial complexity: re providers of finance*
- *Socio-political complexity: notably managing stakeholders*

STRATEGIC BUSINESS OUTCOMES (SBOs)
- Conflicting SBOs
- Scope/reach of defined outcomes
- Owner complexity (JV; alliance; state owner enterprise)

TEMPORAL complexities
- SBO migration over time
- Competitive landscape changes
- Market migration

GOALS uncertainties
- Ambiguity, visibility, poor alignment
- Economic susceptibility (local, global)

TECHNOLOGICAL *AND METHODS uncertainties*
- New processes
- New tools
- IT complexity
- Technical design basis not fixed
- Prototyping, planning, and analysis inadequate
- Specialised materials or skills
- Limited number of suppliers
- Systems integration extent

PROJECT PORTFOLIO *[STRUCTURAL complexities]*
- Number of projects
- Precedences and interdependencies
- Uncertainties of assumptions and data
- Sophistication of modelling and analysis
- Assumption migration
- Definition of "white space"
- Number of constraints
- *Emergent sources of complexities*

PROGRAM/*PROJECT* EXECUTION
- Cyclomatic complexity
- Structural complexity of plan, WBS, and schedule
- Degree of shared constraints (first; second; third order)
- Degree of constraint coupling (direct and indirect)
- Number of changes
- Supply chain resiliency; extent of common failure modes (common sub-tier sourcing)
- Depth of labour pool (total and critical skills)
- Labour predictability (labour action; productivity)
- Physical complexity of projects comprising the program (footprint; degree of temporary construction; duration of discrete work activities, duration of transition phases)
- Specialised equipment availability and lead times
- Permitting and regulatory complexity; timeliness
- Logistical congestion and chokepoints
- Flexibility of sequencing
- Financial and financing constraints
- Regulatory constraints
- Management tools and systems not adequately integrated
- Shallow risk management
- Extent of feedback mechanisms
- Distance of projects and key supply locations from day-to-day operations
- *Contract complexity*
- *Complexity re the management and operating systems*
- *Pace – urgency and criticality of time goals*

ORGANIZATIONAL *AND PEOPLE*
- Shared understanding of program management inadequate
- Clarity of roles and responsibilities inadequate
- Resistance to change
- Value destroying processes and procedures
- Lack of sense of urgency
- Stress level; team fatigue
- Silos that impact communication and knowledge sharing
- Cultural issues
- Number of locations
- Distance of program from day-to-day business
- Workshare systems and process experience and effectiveness inadequate
- Duplication of efforts (Owner/PMC)
- Duplication of efforts (PMC/suppliers)
- Risk aversion vs. risk management
- *Number and variety of interfaces between project and other organizational entities*
- *Complexity of the project's leadership*
- *The cultural and political dynamics within the project team*
- *Individual complexity: the ways in which individuals operating in the organization experience/deal with complexity*

Figure 12: A basic checklist of sources of complexity in the program/project context

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The checklist in Figure 12 is very substantial, although undoubtedly far from comprehensive. But it is certainly wide-ranging, and should provide a reasonably sound basis for others to use, and/or to build on.

CONCLUDING

This article has been very much an exploratory one for me. In the Introduction, I suggested we might be able to develop a combined checklist of sources of complexity. We have indeed done this, as shown in Figure 12.

Overall, I hope at least some of the materials in this article may be useful to others who have an interest in trying to get their arms around a topic which is more than a little complex in its own right.

In the next issue of this journal I propose to discuss relationships between complication and complexity in the program/project context. In a later series on non-traditional project management guidelines, I will be discussing what various authors have had to say about the management of certain types of program/project complexity. These will still barely scratch the surface of what is a huge topic, and one which is a major challenge for project management to really come to grips with.

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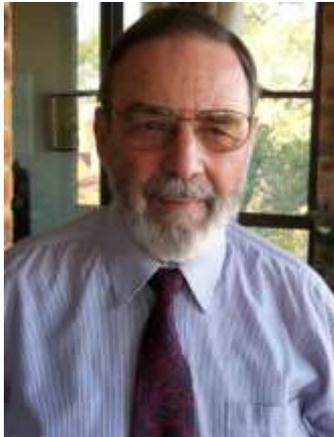
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About the Author

Alan Stretton, PhD

Faculty Corps, University of Management
and Technology, Arlington, VA (USA)

Life Fellow, AIPM (Australia)

Alan Stretton is one of the pioneers of modern project management. He is currently a member of the Faculty Corps for the University of Management & Technology (UMT), USA. In 2006 he retired from a position as Adjunct Professor of Project Management in the Faculty of Design, Architecture and Building at the University of Technology, Sydney (UTS), Australia, which he joined in 1988 to develop and deliver a Master of Project Management program.   Prior to joining UTS, Mr. Stretton worked in the building and construction industries in Australia, New Zealand and the USA for some 38 years, which included the project management of construction, R&D, introduction of information and control systems, internal management education programs and organizational change projects. He has degrees in Civil Engineering (BE, Tasmania) and Mathematics (MA, Oxford), and an honorary PhD in strategy, programme and project management (ESC, Lille, France). Alan was Chairman of the Standards (PMBOK) Committee of the Project Management Institute (PMI®) from late 1989 to early 1992. He held a similar position with the Australian Institute of Project Management (AIPM), and was elected a Life Fellow of AIPM in 1996. He was a member of the Core Working Group in the development of the Australian National Competency Standards for Project Management. He has published over 170 professional articles and papers. Alan can be contacted at alanailene@bigpond.com.au.