

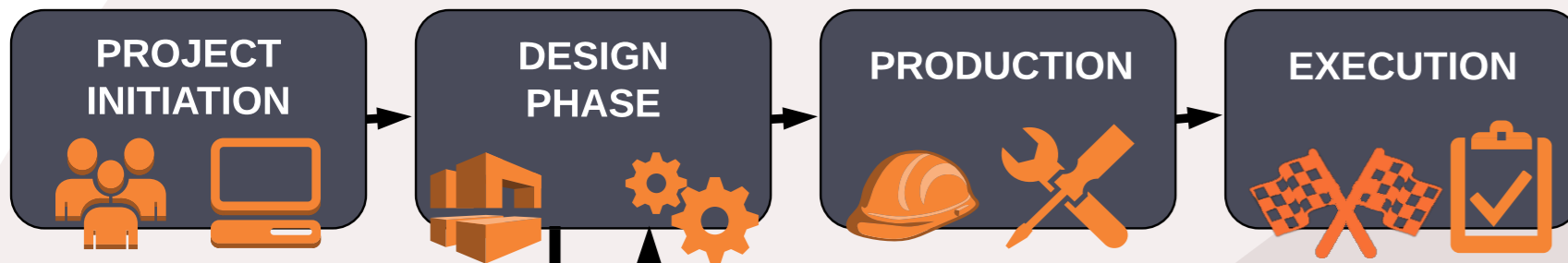
Jordan Haddrick U5826096 | Liam Knott U5825169 | Luke Magyar U5802436 | Dillon McGrath U5784121 | Emily Rose Rees U5812108 | Weiyue Wang U5889098 | Kenneth Zhang U5624541

Logistics deals with the organisation and implementation of a complex process, including many resources and thus was viewed as a critical branch of systems engineering. The efficiency and performance of a large system is often highly dependent on good logistical coordination.¹

- This makes logistical planning and coordination a crucial component of engineering projects.

ANU's entry into the World Solar Challenge² is an example of such a project as it encompasses a large number of people, departments and engineering disciplines.³

- The project is currently in the planning and design phase, which includes developing a transport solution.



- ✓ Within Budget
- ✓ Reliable
- ✓ Sufficient Space
- ✓ Adaptable
- ✓ Comfortable
- ✓ Aesthetics

Transport logistics became the focus as:

- it forms a critical basis for subsequent in-depth design and integration
- dictates some of the design decisions the ANU WSC Team will be required to make in the near future

Systems engineering was a powerful approach as it:

- Reduced the complexity and breadth of the problem scope.
- Created a solution which emphasises flexibility, efficiency, coordination and organisation of transport, rather than technical design.
- Addressed fundamental problems by prioritising long-term solutions.
- Provides the most measured, researched and implementable solution.

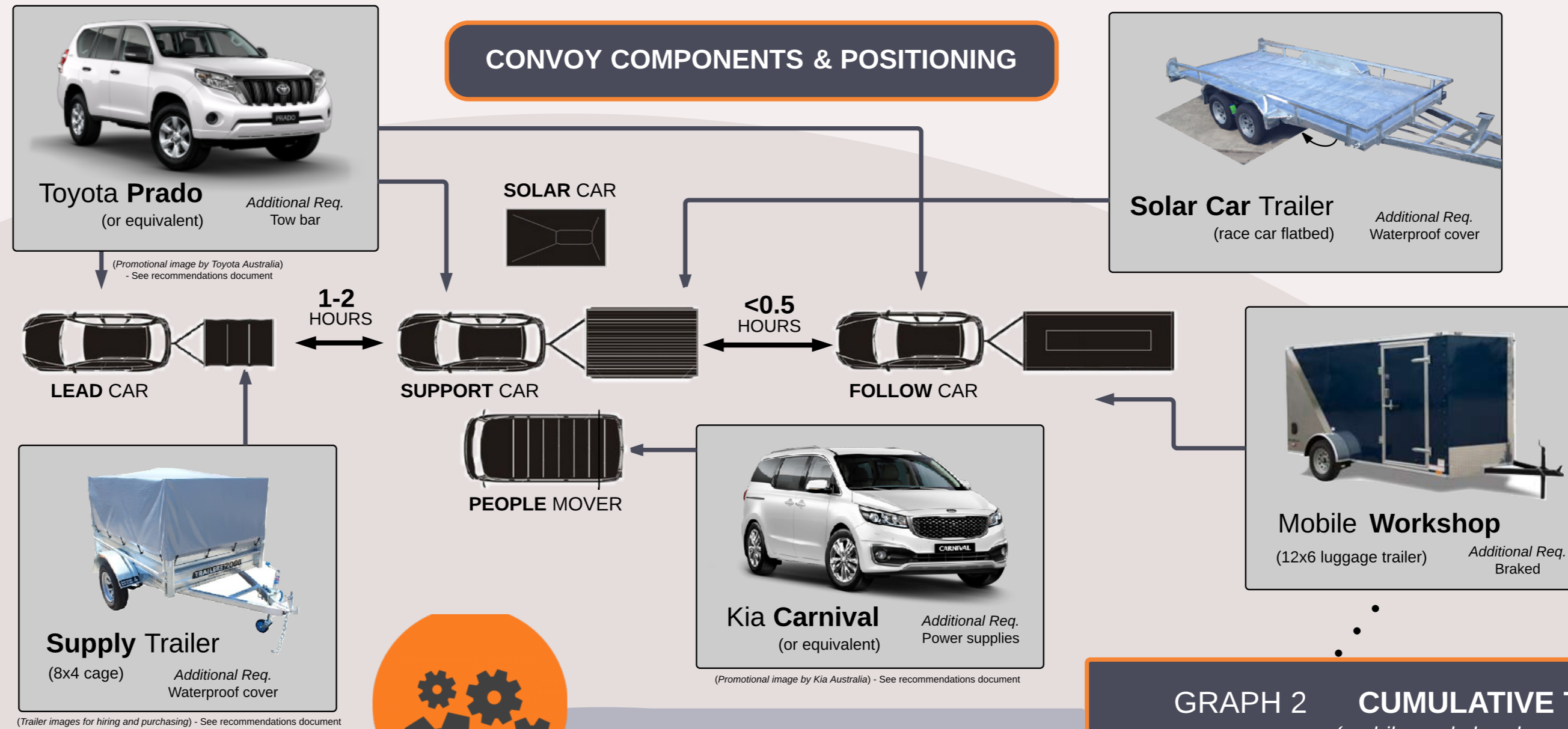
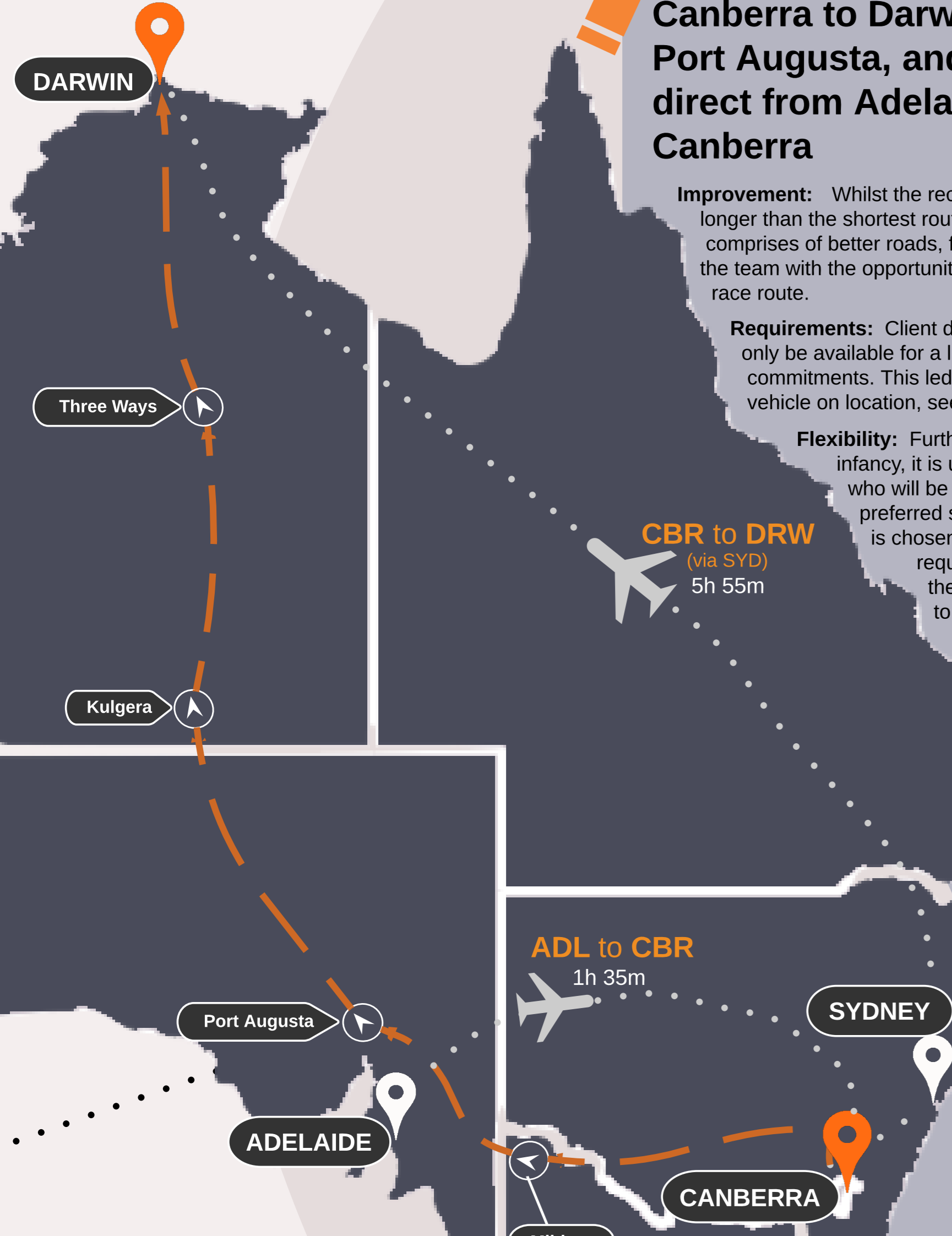
1 ROUTE

Canberra to Darwin via Port Augusta, and return direct from Adelaide to Canberra

Improvement: Whilst the recommended route is two hours longer than the shortest route (through Queensland), it comprises of better roads, facilities and services. It also provides the team with the opportunity to test and become familiar with the race route.

Requirements: Client discussions indicated some personnel may only be available for a limited period of the competition due to other commitments. This led to the suggestion of direct flights and hiring a vehicle on location, see map left.

Flexibility: Furthermore, as the ANU WSC Team is in its infancy, it is unsure of the exact number of personnel who will be travelling. A flexible solution was preferred such that regardless of which flight option is chosen (see Graph 1), the convoy will not require further alteration. It is recommended the 4 most limited team members are flown to and from the event, but Graph 1 highlights the flight costs and the subsequent effect on food costs for other likely scenarios as well.



2 CONVOY

3 large 4WD vehicles, 3 assorted trailers and a people mover

Space: Initially space was considered the primary objective, and the severity of conditions dictated a robust vehicle. Large trucks were initially considered the most viable, however due to the driving license limitations of trucks, vehicles and trailers were favoured.

Modularity: As vehicles and trailers (see above) can be separated unlike trucks, they provide modularity in both operation and sourcing. 4WD vehicles are also more familiar to the users and research shows user centered solutions are more successful in the long term.⁴



5 ADVANCE

Book vehicles and flights as soon as possible

Cost: Booking in advance lowers the cost of plane tickets and hire vehicles which helps the solution comply with the strict low budget set by the customer.

Advantages: The benefits of advanced booking outweigh the minimal reduction in flexibility. Advance booking:

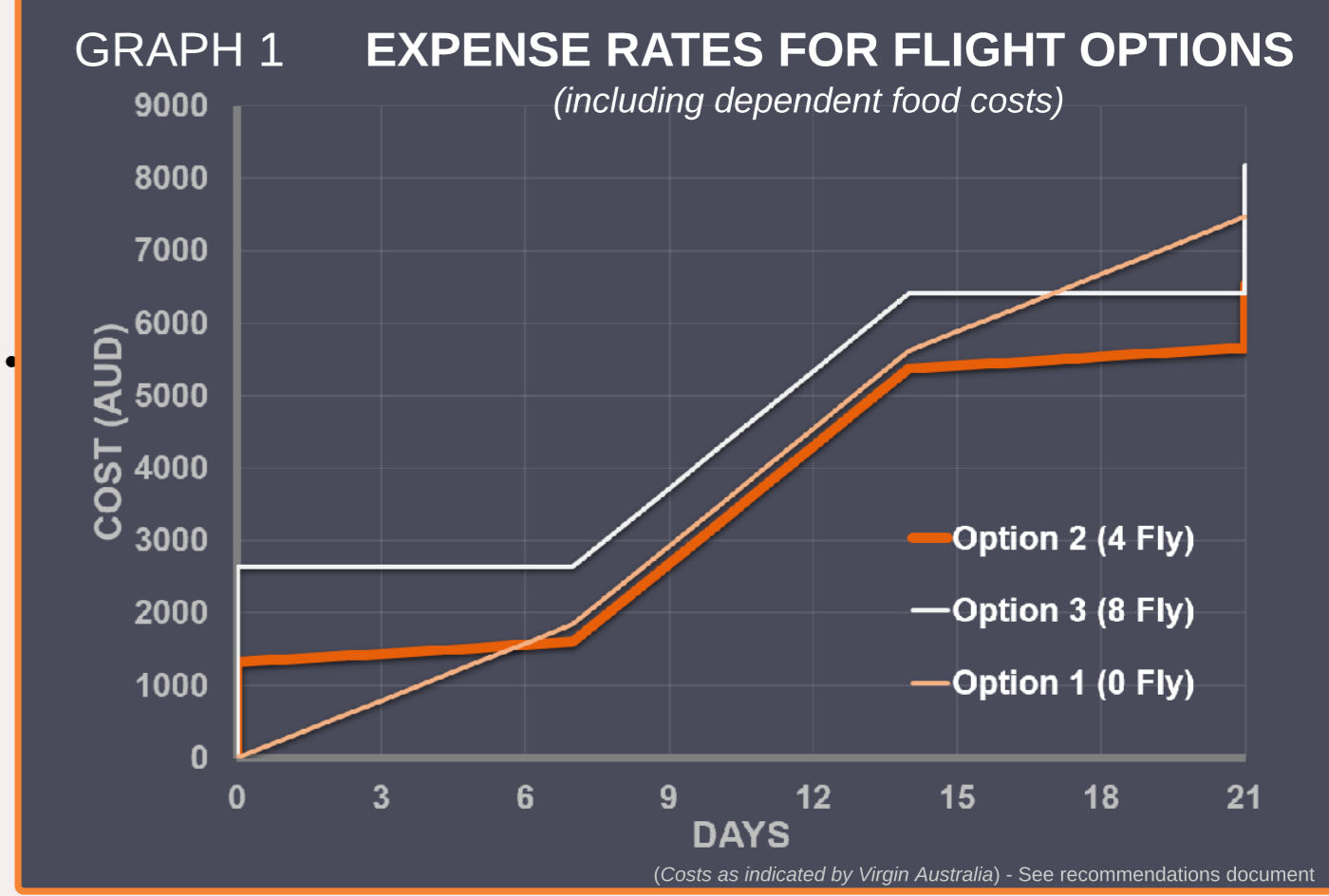
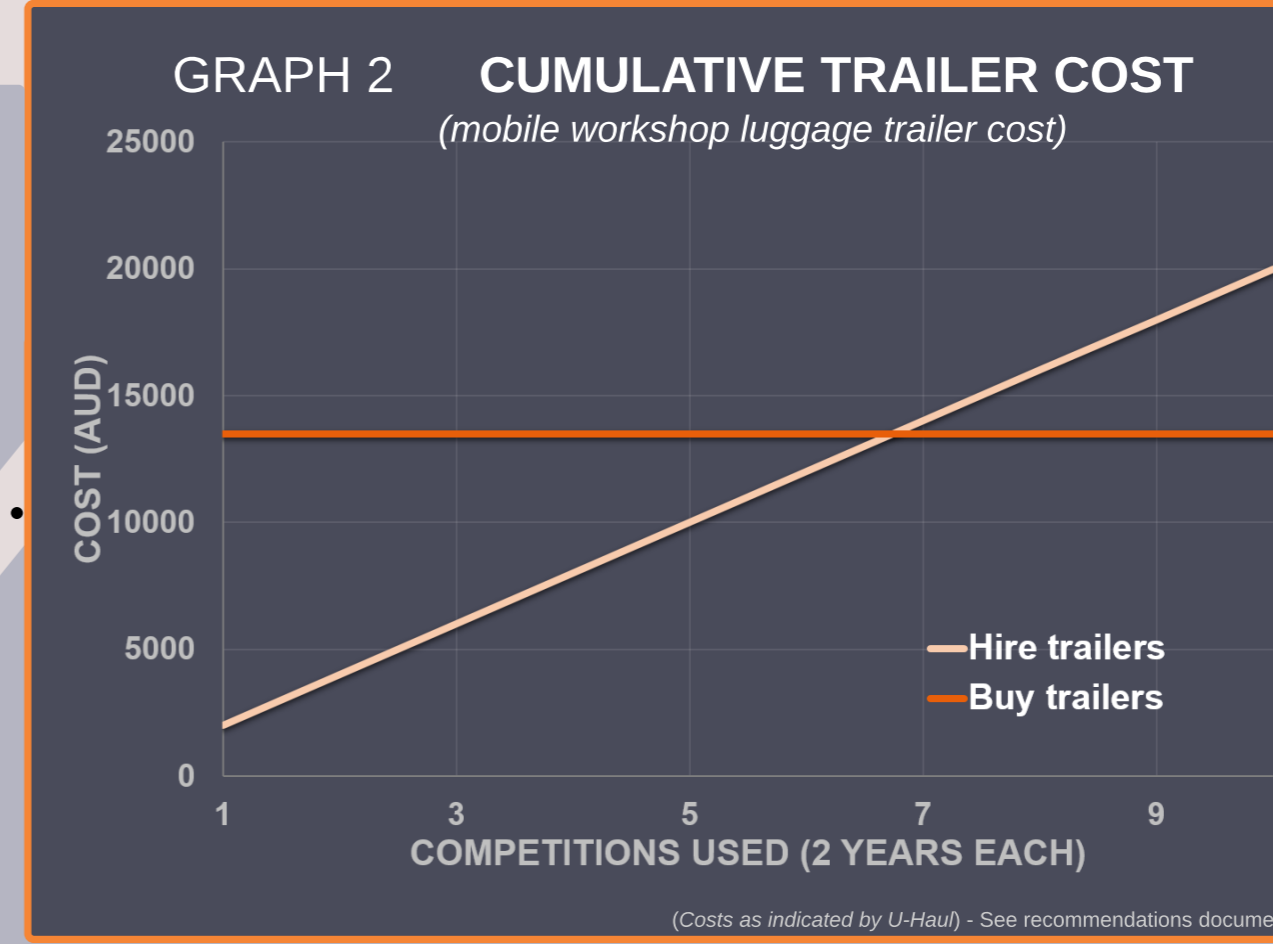
- Forces concrete plans to be made, including commitment of funds and personnel
- Indicates luggage and storage limitations early on
- Allows informed design decisions to be made
- Reduces stress and complications
- Guarantees the required components, trailers and vehicles will be available despite high local demand.

3 UPFRONT

Optimise initial spending and minimise reoccurring costs

Convenience: Whilst the cost of purchasing the workshop trailer outright will only be equalled by ongoing hire costs after 7 competitions (14 years), significant benefits exist. Purchasing the workshop trailer outright allows for greater customisation of the work space, and for the workshop to be fitted out well in advance of the competition, remain accessible on site at ANU and be used as a hub for work and demonstration by the ANU WSC team. Investigation has indicated that ANU has a number of vehicles (as part of ANU CarShare), and there is potential for using these vehicles rather than hiring from an external source which would also favour upfront long term investment to ongoing costs.

Insurance: Purchasing additional consumables including food and fuel will minimise unexpected costs and stops during the race. This will also provide insurance in the case of a local shortage which is plausible considering the remote location.



Limitations: Cost comparisons, such as those used to highlight the payback on outright purchases (Graph 2) and flight options (Graph 1) do not account for inflation and may become outdated if the findings are implemented in the distant future.

Role: This project has placed emphasis on the high-level co-ordination of a logistics transport system. It forms a crucial component of the design and planning phase of the ANU WSC project, however further investigation will be required to explore critical details.

Future Work: The next phase of the transport design would be built around establishing precise metrics with the client, including:

- Number of personnel travelling
- Luggage allowances
- Dimensions of solar car
- Dates of travel

As these aspects will only become clear immediately before the competition the systems engineering analysis conducted presented here will be a critical framework.

4 CONTENTS

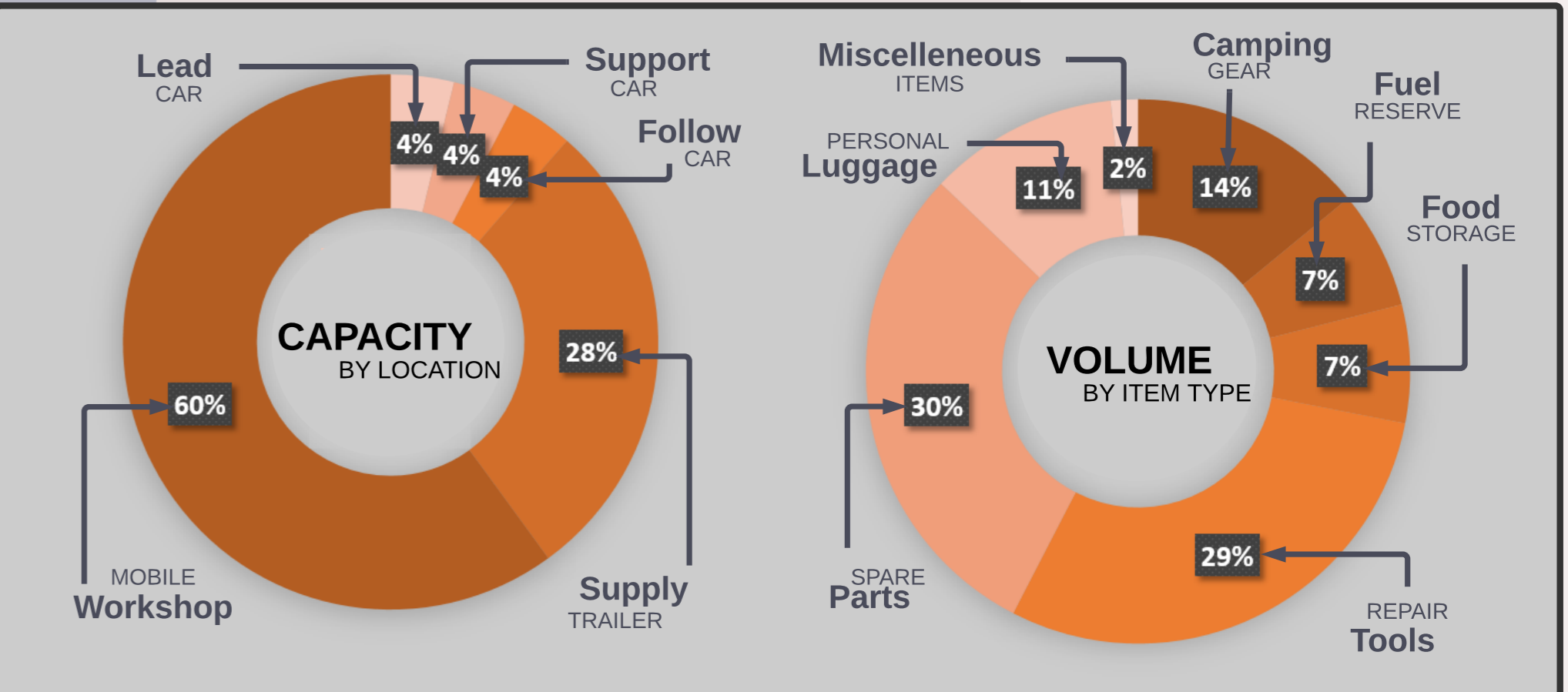
Efficient organisation of convoy, people and contents

Table 1 Location of potentially critical equipment

Location	Item
Lead Vehicle	Tents, cooking equipment, food supplies, additional supplies
Follow Vehicle	Spare parts, workshop equipment
All	Water supplies (proportional to number of passengers), first aid supplies, fuel supplies (enough for one day)

Location: Safety, convenience and accessibility must be prioritised, for example first aid equipment should be distributed throughout the convoy but crucial tools must be in the support car.

Personnel: Seating arrangements also have certain limitations; mechanics and solar car drivers need to be located close to the solar car throughout the race.



CONCLUSIONS The investigation examined transport logistics and the results form the basis for ANU's WSC 2017 transport solution. The logistics proposal is built around the client (ANU WSC) requirements of low cost, spacious, reliable, flexible, comfortable and professional. Our investigation has provided five key recommendations for route selection, convoy components, upfront and advanced purchasing and the organisation of contents.

¹ Spencer, R. W 2014, Managing complexity, Research Technology Management, Vol. 57, Issue 3, pp.53-65
² World Solar Car Challenge, 2016, <http://www.worldsolarchallenge.org/>
³ Doonan, M 2016, Personal Communication, WSC Client Meeting, Monday 29th February
⁴ Alnam, T. Z, Karwowski, W & Arnabaz, B 2010, User-centred systems engineering approach to design and modelling of smarter products, System of Systems Engineering (SoSE), 2010 5th International Conference Systems, Loughborough, pp.1-6