The Gondwanans have aptly described the project as “SILVER”. For them it has a high value and a high priority for resolution.

THE CHALLENGE:
The challenge is to design a prototype system to move the replenishment sphere (payload) from a store to the intended height datum on the balloon tether.

Fortunately, teams of engineering students from Earth are about to visit Gondwana as part of their work experience programmes. On 24 previous visits such engineering students have rendered invaluable assistance with solutions to similar engineering problems, and the Gondwanans again are hoping to benefit from the ideas of the innovative budding engineers. To celebrate the assistance from Earth, a special SILVER Anniversary event is planned to coincide with the conclusion of the tender process.

**Objective**
The objective is to design, build and prove a prototype system in a laboratory environment that serves to deliver autonomously a supply package to a balloon based observation facility, using the balloon tether to deliver the supply package?

In context, can you design the best system to *Strategically Innovate for Laterally and Vertically Effected Replenishment*?

Can you assist in Project SILVER?

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Details follow:
- Competition Guidelines
- Competition Rules
- Frequently Asked Questions
- Further Competition Details
- Spirit of the Competition

**Document Control**
* Version 1.0  
* 13/12/2011
**Competition Guidelines**

*(Version 1 Released: 13/12/2011)*

**ELIGIBILITY**

G 1. Teams of notionally four first or second-year, nominally mechanical-engineering students, in Australian or New Zealand universities (or other universities by arrangement), may enter the competition. Teams of three or four are strongly recommended.

**NOTE:** It is recognised that some campuses are using the Warman as a 1st Year project and that team sizes may be necessarily forced for logistic reasons to be larger than 4. Both year and size variations are acceptable.

**SAFETY**

G 2. Safety is of paramount importance when participating in this competition. All engineers should know that injury and damage to equipment and the environment occurs when the control of energy in a system is lost.

G 3. As appropriate, protective clothing, footwear, safety glasses or full face masks should be worn by students working on systems during construction, during testing, and during competitions.

G 4. Students are encouraged to carry out a risk assessment for their system prior to campus testing. Students are encouraged to embrace risk management in their own activities and may need to demonstrate safe operation and produce risk assessment documentation in order to compete in either the campus heat or at the National Final.

G 5. Compressed gas systems may be used but students must gain local coordinator approval based on a safety assessment.

*Such systems presented at the National Final will be examined against the following principles and must be acceptable to the National Coordinator.*

- Home fabricated pressure system components are not to be used unless the pressure is considered to be low.
- Commercial components should be used (unions, vessels, cylinders, lines) unless the pressure is low.
- Up to 550 kPa (approx 80 psi) may be considered low pressure if such pressure is held inside a plastic drink bottle pressurised by a bike pump. Such a system must be well constrained to prevent projectiles exiting in the event of a failure. For example, an outer, non-pressurised shield shall be included over plastic bottle pressure vessels, to take any sting out of a rupture.
- Evidence of proof testing of compressed gas systems shall be provided.
COMPETITION TRACK, EQUIPMENT AND ENVIRONMENT

G 6. The competition track shall be fabricated using primarily two sheets of Medium Density Fibreboard (MDF), each with nominal dimensions 2400 x 1200 x 18 mm, arranged end to end as shown in Figure 1 and Figure 2. The supporting frame for these sheets may be fabricated by any convenient method.

**NOTE:** The MDF sheets as supplied in the ACT are slightly larger than the nominal 2400 x 1200 dimensions. They are 2420 x 1210. They do not need to be cut down. The 12 x 12 DAR fences (see rule G17) on the board extremities are flush with the edge of the as supplied boards.

G 7. The two MDF sheets and relevant attached features are identified respectively as track segments 1 and 2 and collectively as the competition “track”.

G 8. The tops of the two primary MDF sheets shall collectively define the competition base plane which is nominally horizontal. The heights of the track segments shall be adjusted so that there is no step between the two track segments.

G 9. The competition base plane shall be no less than 200 mm above the supporting floor at the National Final.

G 10. Track segment 1 contains the “start zone” at one end which is representative of a hangar or shed. It presents a rectangular doorway from the start zone modelled by a timber arch. The “external” surface of the arch is aligned coincident with the centreline of the sheet. An indicative low wall of the start zone will be formed with 90x35 pine timber as shown.

G 11. Track segment 2 joins with track segment 1 and at its free end; the “balloon tether” is arranged vertically, suspended from a gantry or other available structure.

G 12. The arrangement for supporting the tether is to provide a rigid support and must not restrict a volume above the base plane of the track defined by a height of 2000 mm and a track side offset of 200.

G 13. The tether comprised of 8mm braided polypropylene sash cord will pass through the track base plane and be constrained by the underside of the sheet with a knot in its end. The tether will rise vertically and lead over a pulley system. From the free end of the tether a 4kg mass will be suspended to provide tension.

G 14. At a height of 1800 mm above the base plane of the track, the tether will pass through a stop approximately 50mm outside diameter formed from 2 inch OD tube. This stop marks the end of the intended ascent.

G 15. An indicative tether support system is shown in Figures 1 and 2. Bracing between the tether support system and the track is recommended but any such bracing is to be well below the base plane of the track.

G 16. A 20 litre bucket as depicted in Figure 3 will be modified by removal of the handle and by cutting a hole of 76 mm (3 inch) diameter in the centre of its base. The
bucket will be constrained by three fixed blocks of 100x90x35 pine timber as shown in Figures 1 and 2 such that the tether passes through the hole in the bucket and is coincident with the axis of the bucket.

**NOTE:** The bucket, available from Bunnings, is a “20 litre heavy duty bucket with handle (black or white)” and is identified by a Fine Line Reference Number: 4460449. A sample was purchased in Canberra for $4.50.

**FIGURE 1 – ISOMETRIC VIEW OF THE PROJECT “SILVER” COMPETITION TRACK**
FIGURE 2 - PROJECT “SILVER” COMPETITION TRACK
G 17. A low wall formed with 90x35 pine timber is positioned transversely at the end of track segment 1 adjacent to the join with track segment 2. It spans half the track.

G 18. Adjacent to the start zone but outside it as shown in Figures 1 and 2, the longitudinal edges of track segment 1 shall be fenced with 12 x 12 DAR (Dressed All Round) timber strips mounted on the top (track base plane) with their outside edges flush with the sheet edges. The strips will be mounted by countersunk screws (100 mm spacing) on the top surface of the sheets.

**NOTE:** The 12 x 12 DAR fences should be considered as guides rather than barriers built to resist high collision loads. Damaging the fences is considered to be damaging the competition site and will cause a zero run score to be recorded.

G 19. All exposed surfaces of the MDF and timber will be brush coated with one coat of Wattyl Water Based Estapol Clear – Satin followed by two coats of Wattyl Estapol Matt.

G 20. The payload used for the competition will be a regulation 12 inch softball ball.
NOTE: As defined in the Official Rules of Softball, the completed 30.5cm (12 in) ball shall be between 30.2cm (11 7/8 in) and 30.8cm (12 1/8 in) in circumference, and shall weigh between 178.0g (6 1/4 ounces) and 198.4g (7 ounces).

G 21. A “Fix-a-Tap” sink strainer and table tennis ball will also be integrated with the system and employed as a “motion sensor”.

NOTE: The sink strainer is available in a range of hardware and plumbing supply stores including Bunnings. A sample was purchased in Canberra for $2.00.

G 22. Teams must accept that the presence of bright lighting and photography including flash and infrared systems are part of the competition environment.
PROTOTYPE SYSTEM

G 23. Participating teams shall present a prototype system that serves to transfer a payload on the defined track in accordance with the rules.

G 24. The payload, initially located with Subsystem A, is intended to be transferred to another subsystem, Subsystem B, which will then raise the top of the payload to a height of 1800mm above the base plane of the track and hold it indefinitely in that position.

G 25. Subsystem A will be initially staged in the start zone and be fully supported by the base plane of the track.

G 26. Subsystem B will be initially staged within the bucket and attached to the tether.

G 27. Systems that are deemed by the officials and judges to be hazardous will not be permitted to run. Employing any form of combustion is considered hazardous.

G 28. Systems that are deemed by the officials and judges to damage or have the capacity to damage the track or its features will not be permitted to run or will be disqualified.

G 29. Campus organisers are free to modify the rules and or competition track for their local competition but the guidelines and rules as stated shall be strictly adhered to at the National Final.

RULE WORDING

G 30. The language of the rules is tiered. Those clauses expressed as “SHALL” are mandatory and failure to comply will attract penalties which in the extreme could lead to disqualification. Those expressed as “SHOULD” or “MAY” reflect some level of discretion and choice.
Competition Rules

MATERIALS AND MANUFACTURE

R 1. Students SHALL manufacture and fabricate their prototype system themselves using commonly available materials, components and methods.

NOTE: At the National Final Campus Organisers may be required to confirm that the systems presented have been appropriately manufactured in keeping with the spirit of the competition.

R 2. Teams SHALL present a system comprising two Subsystems, A and B.

R 3. One Subsystem at least SHALL be “purely mechanical” (using no chemical energy (including batteries) and having no functioning electrical or electronic components). The other Subsystem MAY utilise electrical or electronic power and circuitry.

PROCEDURE

R 4. The mass of the team’s system will be measured by an official. The system gross mass SHALL NOT be greater than 8 kilograms.

R 5. Contact SHALL NOT be made by team members or their system with the competition track before official setup commences.

R 6. The team will be called to the track side and, when ready, an official will signal that the initial setup time has commenced. The team SHALL be allowed a maximum of 120 seconds for initial setup. In this time they are to set up their system (both Subsystem A and Subsystem B).

R 7. Contact SHALL only be made by team members or their system with the competition track areas at either end of the track during setup, within the start zone and in close proximity to the bucket and tether.

R 8. The tether SHALL NOT be unthreaded in order to attach Subsystem B. However, the pre-tensioning mass MAY be removed and the tether slackened and moved from the vertical if desired. The bucket MAY also be moved.

R 9. During setup the team MAY use, for the purposes of setup, additional objects not considered part of the “system”.

R 10. During setup the team SHALL if moved, restore the pre-tensioning mass and bucket.

R 11. The team SHALL indicate to the appropriate official when their setup is complete.
R 12. After initial setup and prior to running, everything placed and left on
the competition track SHALL be considered to be part of the system.

R 13. After initial setup, the system will be subject to volume constraints. For a valid
run, Subsystem A SHALL be wholly contained within the start zone as defined by the
internal faces of the arch and wall and the track edges. Subsystem B SHALL be wholly
contained within the bucket and SHALL NOT project above the bucket rim. The
placement and volume conditions will be physically checked by an official.

R 14. The payload SHALL then be presented to the team for placement on or in
Subsystem A. The payload SHALL NOT be modified in any way and should be clearly
visible in order to measure its position as necessary.

R 15. A sink strainer and table tennis ball SHALL then also be presented to the team for
placement on Subsystem B. Its function is as a motion smoothness sensor. The strainer
SHALL be configured with the concavity upward and the table tennis ball SHALL sit in
the concavity. The strainer and table tennis ball SHALL NOT be modified in any way
and the strainer SHALL only be supported from below. The strainer SHALL NOT be
fixed in any way to Subsystem B and no part of Device B SHALL be above the top edge
of the strainer.

R 16. At this time, the strainer and the table tennis ball MAY project above the rim of
the bucket but they SHALL NOT project beyond the internal circumference of the bucket
rim.

R 17. The free movement of the table tennis ball SHALL NOT be restricted in anyway
and there SHALL be clear space horizontally around and above the full circumference of
the strainer greater than the diameter of the table tennis ball.

R 18. Subsystem B SHALL NOT incorporate any device that is capable of returning the
table tennis ball to the strainer should the ball leave the strainer.

R 19. The team SHALL be allowed a maximum of 60 seconds for final setup (addition
of payload, strainer and table tennis ball).

R 20. After final setup and prior to running, the system SHALL be both stationary and
satisfy the volume conditions which will again be physically checked by an official.

R 21. After set up and prior to running, the system SHALL NOT be held or supported
or contacted by anything other than the competition base plane and bucket and tether and
it must be ready to start. This prohibits team members from restraining by personal
contact a ready-to-release system. Systems should be capable of remaining in the set up
condition indefinitely.

R 22. On instruction and by a signal from the “official starter”, the run will commence.
A valid run SHALL finish with a run time less than 120 seconds. This will be judged by
an official.
R 23. Subsystem A SHALL be started using a single action that does not impart motion or energy to the system. A single-action start may employ a simple instrument not considered part of the system, e.g. using a pair of scissors.

R 24. With two exceptions (see following rules), after performing the single-action start, team members SHALL NOT control or touch the system in any way during the run. Wireless control is specifically prohibited. If team members choose to intervene to protect a system that is malfunctioning, a zero score for the run shall be recorded.

R 25. The first exception is that if Subsystem A fails to interact autonomously and successfully with Subsystem B, teams will be given a second payload and SHALL trigger Subsystem B by mimicking the intended transfer method manually. If such an intervention is executed, the score recorded will be discounted in accordance with the rules.

R 26. The second exception is that if in manually transferring the payload Subsystem B is not triggered, teams SHALL manually trigger Subsystem B by mimicking the intended trigger method. If such an intervention is executed, the score recorded will be discounted in accordance with the rules.

R 27. During the run the system SHALL NOT come into contact with anything below the competition base plane or any structures outside the defined clear volume surrounding the track.

R 28. During the run, Subsystem A SHALL only operate through the doorway of the start zone. The start zone is to be considered to represent an enclosed hangar or shed.

R 29. During the run, the payload SHALL be transferred from Subsystem A to Subsystem B.

R 30. Subsystem B SHALL NOT begin movement until it is in possession of the payload.

R 31. Subsystem B MAY contact the stop but SHALL NOT grasp it or its supporting structure.

R 32. During a valid run, the payload and the table tennis ball SHALL track such that they experience the same motions. The payload and strainer supports SHALL be rigidly connected to mimic linear and rotational accelerations, velocities and displacements.

R 33. At the completion of the run and for the run to be valid, all of Subsystem B and the payload SHALL NOT be within or in contact with the bucket.

R 34. At the completion of the run and for the run to be valid, Subsystem B and the payload SHALL be fully supported by the tether.

R 35. At the completion of the run, if the table tennis ball is not in the strainer or the strainer is not supported in its original position relative to the Subsystem B, the score recorded SHALL be discounted in accordance with the rules.
R 36. At the completion of the run, the overall system SHALL cease both translation on
the competition track and gross motion above the competition base plane and remain in
this state indefinitely relative to the competition track. Mechanisms and items in the
system may continue to move but no further functions can be executed.

R 37. The team will indicate to the timekeepers when they declare their run to be
complete. However, the time keepers SHALL make the final judgment as to when the
system ceases translation, rotation and all functions have ceased. The recorded time may
exceed the team’s declaration.

R 38. The recorded run time MAY be an aggregate of two times if a manual
intermediate operation is necessary. Any secondary manual action SHALL be controlled
and directed by an official.

R 39. The recorded height to the top of the payload SHALL be measured by an official.
The payload is to be appropriately visible to make this measurement.

R 40. To ensure that judging has been completed teams SHALL NOT retrieve their
system or assist in gathering other items until directed by an official.

R 41. Subsystem B SHALL be retrieved by removing the pre-tensioning mass providing
slackness in the tether, not by standing on the track or by climbing ladders etc.

R 42. Systems SHALL NOT damage or contaminate the competition track. Teams
presenting systems that damage the track may be disqualified from the competition.

EXPLANATORY NOTE: A component of the system left simply on the competition track
does not constitute contamination. An example of contamination would be a sticky
residue requiring significant effort to remove it, with the possibility of permanent change
occurring to the surface finish.

R 43. As directed, teams MAY attempt two runs.

R 44. The system MAY be modified between runs but the mass, volume and time
constraints must be satisfied for a run to achieve a valid non-zero run score.

R 45. Violations of procedural rules SHALL result in a zero run score being recorded.

R 46. The judges’ decisions on all matters pertaining to the competition SHALL be
final.
SCORING

R 47. Better systems will achieve the objectives of transporting the payload with higher effectiveness whilst adhering to the timing, volume and positioning constraints. A valid run score SHALL be calculated using the following formula and is based on the end state of the payload. The maximum run score is 100. A run and scoring flowchart is shown in Figure 5.

**VALID RUN SCORE**

\[
VALID\ RUN\ SCORE = ACONTROL \times \left(1 - \frac{\sqrt{DIST}}{\sqrt{400}}\right) \times 50 \times \text{TRANS} + \\
BCONTROL \times \left(1 - \frac{\sqrt{DEL-1}}{\sqrt{150}}\right) \times 50 \times \text{SMOOTH} \times \text{TRIG}
\]

Calculated to one decimal place, where at the end of the run:

- **ACONTROL** = 1 if payload controlled by system at all times up to and including TRANSfer
  0 otherwise

- **BCONTROL** = 1 if payload controlled by system at all times after TRANSfer
  0 otherwise

- **DEL** = Distance of payload in cm from vertical datum (max 150)

- **SMOOTH** = 1 if table tennis ball on strainer with Subsystem B
  0.7 otherwise

- **TRIG** = 1 if Subsystem B autonomously triggered
  0.8 otherwise

- **TRANS** = 1 if payload autonomously transferred between subsystems
  0.98 otherwise

- **TT** = Time in seconds for complete run evolution
  Recorded if TRANSfer or TRIGgering not autonomous

- **DIST** = Distance of payload in cm from bucket rim (max 400)
  = 0 if payload autonomously transferred between subsystems

- **TA** = Time in seconds for Phase 1
- **TB** = Time in seconds for Phase 2
- **TT** = TA+TB
FIGURE 5 - PROJECT "SILVER" RUN AND SCORING FLOWCHART

R 48. DEL SHALL be measured vertically between the top of the payload and the bottom face of the stop on the tether in cm or part thereof.

R 49. DIST SHALL be measured obliquely as the shortest distance between the payload and the rim of the bucket in cm or part thereof.

R 50. SMOOTH SHALL be determined by the final position of the table tennis ball.

R 51. TT MAY be recorded directly or calculated as an addition of TA and TB

R 52. TA SHALL be measured as the time for Subsystem A to cease both translation on the competition track and gross motion above the competition base plane and remain in this state indefinitely relative to the competition track. Mechanisms and items in the subsystem may continue to move but no further functions can be executed.

R 53. TB SHALL be measured as the time for Subsystem B to cease both translation on the competition track and gross motion above the competition base plane and remain in this state indefinitely relative to the competition track. Mechanisms and items in the subsystem may continue to move but no further functions can be executed.
R 54. The Warman Competition Score SHALL be the higher score achieved from either run plus half of the score achieved from the other run and the highest Warman Competition Score will be declared the winner.

R 55. If equal Warman Competition Scores are recorded by teams, teams tied SHALL be ranked based on the RUNTIME of their highest scoring run.

R 56. If the RUNTIMEs of the top ranked teams are within 10 seconds of the fastest, the teams so bracketed SHALL participate in a sudden death run-off to determine the overall places.

R 57. In the event of a run-off, each team will make one run. If an equal score is again recorded, each team will make another run. If after a third such run, the score is still equal; the team with the shortest run time in the third run-off run SHALL be declared the winner.
Frequently Asked Questions
(Version 1 Released: 13/12/2011)

1. Does the system have to stay in contact with the competition track at all times?
   No but the rules do define what can be legally contacted.

2. Can part of a system be “discarded” off the track without penalty?
   No, this would violate the rules and lead to a zero run score.

3. At the end of a run, could a system be supported on the competition track and have a part over the “outside” edges of the track in plan form projection and not receive a penalty?
   Yes, you could have a part in space with no competition track component under it as long as nothing other than legal surfaces of the track are contacted by the system.

4. When is a system deemed to be stationary at the completion of the run?
   The stop instant will be interpreted as the later of when all the contact points between the system and the competition site come to rest and when the functions being performed are observed to have ceased. It must be clear that the system could remain in the end state indefinitely. Some wobbling in the structure is acceptable but gross rotations are not.

5. Autonomous – does this mean that the system on the track can not receive input or instructions from a Subsystem off the track (such as a computer)? Or does it mean that the system on the track can receive input from a Subsystem off the track (such as a computer) but that Subsystem (computer) can not be manipulated by a team member during the run? An example of the second would be if the system was controlled by motors that ran to a pre-programmed route transmitted from the computer.
   Autonomous in this competition implies every control system for the system is to be part of the system on the track and fit within the start volumes. No remote-to-the-track control systems of any sort can be used (manual or pre-programmed, hard wired or wireless). Such configurations would be considered to be part of the system and violate position and volume constraints.

6. Are programmable chips allowed?
   Yes, you can use a programmable chip, but there is to be no remote communication during the run.

7. What is the allowable voltage and power of any employed electrical systems?
   There are no restrictions this year but it clearly needs to be safe.
8. The system mass, SYSMASS, does not influence the scoring. Why is it included?

It is included to validate the maximum mass defined. Failure to comply with the stated maximum mass will result in disqualification. A large mass fundamentally indicates inefficient design. Further, designs needing to be transported to the National Final need to be light and small enough to be accommodated by air travel.

9. Can off-the-shelf items be used?

Commonly available components such as toy and machine parts are able to be used. The spirit of the competition is that students manufacture and fabricate their system themselves, meaning that professionals are not engaged to do it for them. It is possible for some assistance to be obtained (eg for a weld) but this should be minimal or where possible be done by the students themselves. The production of major components should not be outsourced.
Further Competition Details

(Version 1 Released: 13/12/2011)

NATIONAL FINAL

It is planned that the Weir-Warman National Final will be held Friday 28 - Sunday 30 September 2012 in Sydney at a location to be determined.

Prizes for Campus Winners and National Podium Places will be awarded at the National Final. A National Final “Judges’ Prize” and “Design Prize” may also be awarded.

The planned format will have students gathering on Friday morning in Sydney. A tour of Weir Minerals Ltd will follow. Scrutineering and additional judging will be conducted on Saturday and there will be briefings, presentations and practice sessions held on Saturday. The actual running of the Final and the National Final Dinner will be on Sunday.

A team registration form will be available – please submit it to Engineers Australia (EA) as early as possible. Travel arrangements are coordinated by EA. Team details are required early August (unless otherwise advised).

Teams registering and accepting the invitation and sponsorship to participate at the Final also accept that their names and photographs and video of them can be used for publicity purposes by both EA and Weir Minerals. All team members and attending campus organisers will be required to sign an appropriate authority in relation to this use.

In meeting costs, the competition sponsorship funds two students per team. Depending on EA funding, it is hoped that Campus organisers will also be funded. Campuses will be billed for additional students and for people who do not travel but for whom arrangements are made.
Spirit of the Competition

Although the rules may look rigid you will find that they have been written in a way which allows, and in fact encourages, creative and innovative solutions. This is not always the case in real-world engineering projects. In this project and competition, the rules are there because we have tried to be very clear on points which will be important when student groups come together for the National Final. For this reason, it is essential to work with your campus organiser from an early stage, and for the campus organiser to verify decisions with the National Organiser so that everyone has the same understanding of the meaning of the rules.

If you think you see a loophole, clear it with your campus organiser before you rely on it in competition. Even if it is accepted at the local level, you might be in for a shock at the national level where the interpretation might be different. Provision will be made for confidentiality, so your idea will not be passed on to other students.

It is highly recommended that all students communicate with their campus organiser and that if a ruling is required by the National Organiser; this is sought by the campus organiser. Students SHOULD NOT contact the National Organiser directly for an individual ruling.

The competition track will be made with reasonable care but because it is a real engineering object it may well be “wrong” in various small ways. For example the surface might have a slight longitudinal slope. Your team is expected to consider these possibilities in your design, and develop a system that can function even if the competition track has slight imperfections. In other words, you are not allowed to blame failure of your system on some minor imperfection with the competition track.

A FINAL COMMENT ON SAFETY
Please be aware that in 2003 during a campus competition, a student was lucky to escape serious eye injury when a Subsystem went off unexpectedly. While Campus organisers run their own competitions independently, they are strongly encouraged to consider all aspects of safety in relation to the conduct of their competition.