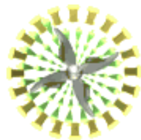
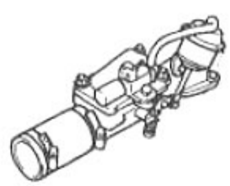
SupraTT - sequential turbo operation



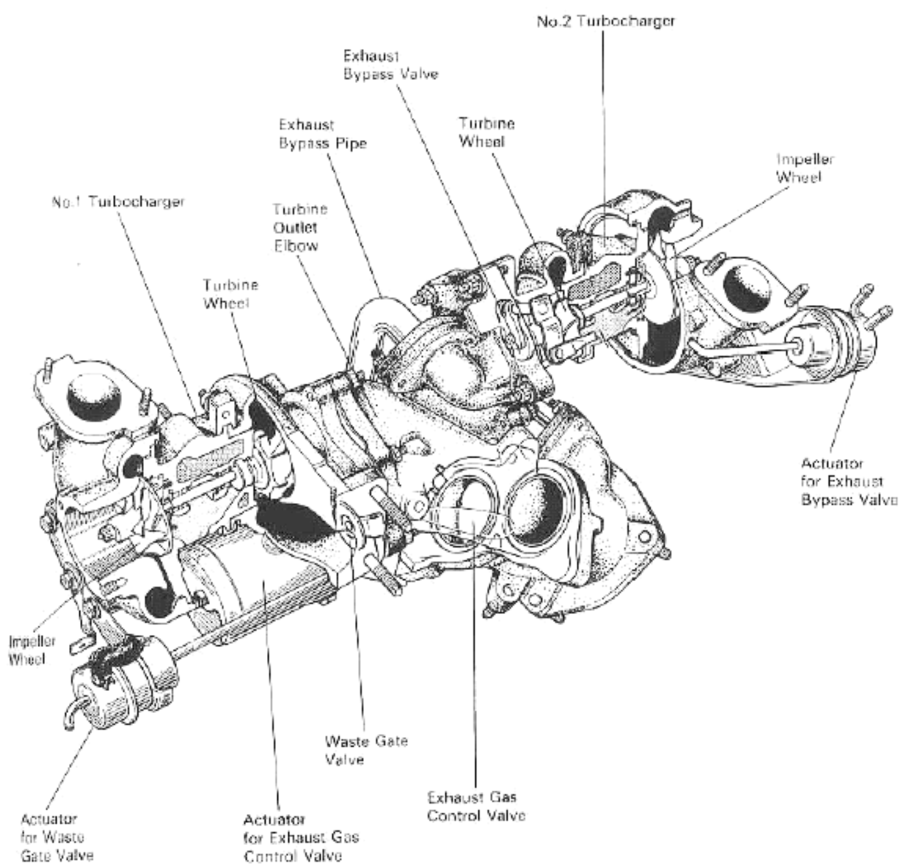
Sequential Symphony in Boost Minor

Performers:

Acronym	Full Name	Function
VSV	Vacuum Switching Valve	2-way valve controlled by a solenoid. Depending on the wishes of the ECU it can be wide open, shut or pulsed open. thus fine-tuning the airflow at the back of its actuator. 
WGV	Waste Gate Valve	Located upstream of turbo#1 it can partially control boost during low-rpm operation and fully control boost during high-rpm operation. It cracks open at 11-12psi and is fully open at 18psi. According to Toyota the diaphram gets damaged at over 27psi. The ECU pulses it open depending on boost pressure, throttle position and engine speed (rpm).
EGCV	Exhaust Gas Control Valve	Located downstream of turbo#2 it controls the flow of exhaust gases via the 'hot' side of turbo #2  It is activated some time between 3 and 4Krpm depending on engine speed (rpm), vehicle speed, intake air volume and intake air temperature.
IACV	Inlet Air Control Valve	Located downstream of turbo#2 it controls the flow of boost pressure via the 'cold' side of turbo #2  It needs 7psi to fully extend. The ECU activates it based on engine speed (rpm), vehicle speed and throttle position.
		Located upstream of turbo#2 it controls the flow of exhaust gases much like the EGCV, which is much bigger though.

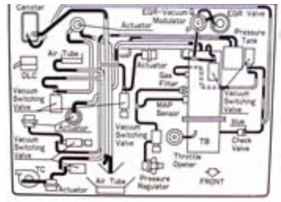
EBV	Exhaust Bypass Valve	During low-rpm operation it partially controls boost along with the WGV. During mid-rpm operation it also controls the pre-spool of turbo#2 During high-rpm operation it cannot control anything, since the wide-open EGCV steals all the 'hot gas' airflow of turbo#2 anyway. Think of the EBV as a small-capacity alternative to the EGCV, only useful for the transition period. The ECU pulses it open depending on boost pressure, throttle position and intake air volume. (Note the absense of engine speed in the mix) According to Toyota it fully extends at 14 psi. (softer spring compared to the WGV). But measuring it shows that it also cracks open at 11psi and is fully open at 17psi, go figure...
	Reed Valve	Located just before the IACV it allows the IACV to be bypassed when it is still closed despite turbo#2 making some boost (mid-rpm operation) Technically it is a simple, passive device that only flows one-way. Hence it needs no actuator of VSV. Think of the reed valve as a small-capacity alternative to the IACV, only useful for the transition period.
	Pressure Tank	It holds pressurised air from the intake so that the IACV and EGCV actuators can be pressurised 

Seating arrangement:



2JZ-GTE VACUUM HOSE ROUTING DIAGRAM

Alternative Toyota diagram for the vacuum lines:



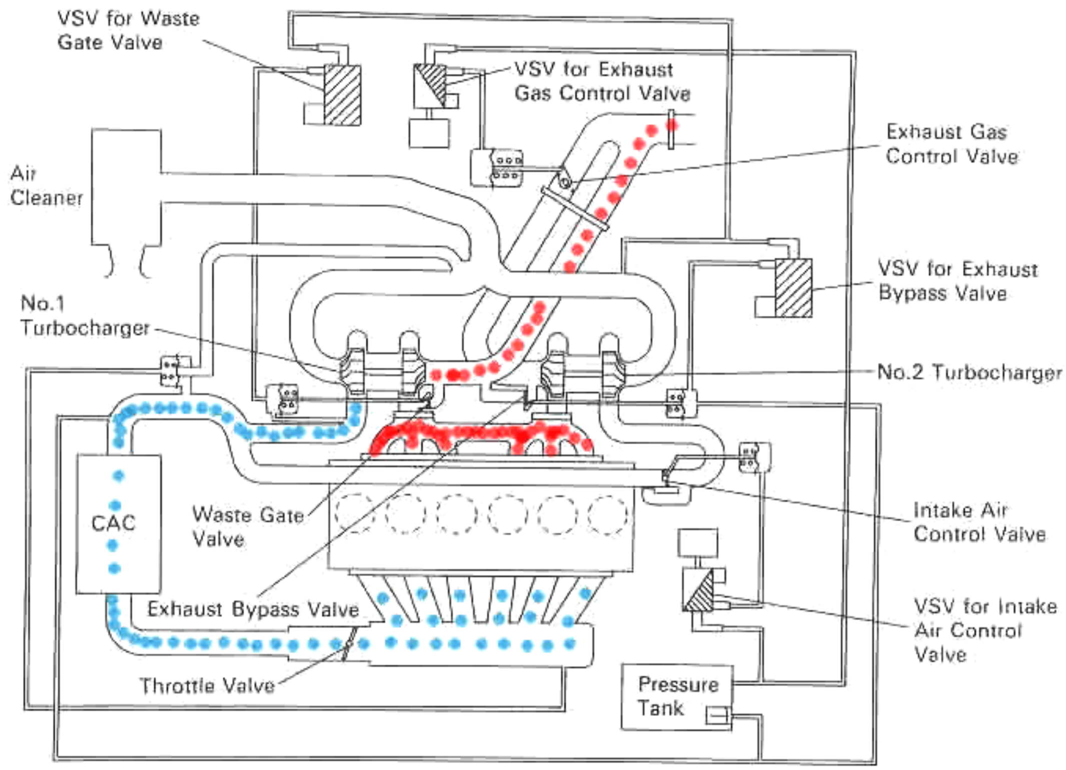
Active diagram with hotspots for each item described in these pages.

Ideal if you need to navigate in the Supra's congested engine bay

1st Movement: Allegro --- Low-rev operation (up to 3500rpm)

EGCV and IACV are shut, so turbo #2 is asleep.

There are two effective wastegate valves at work: the WGV upstream of turbo #1 and the EBV, also upstream of turbo #1.

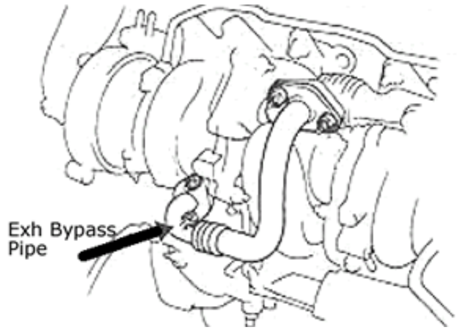


2nd Movement: Molto vivace --- Mid-rev operation (3500-3800rpm)

(Also known as 'prespooling' stage)

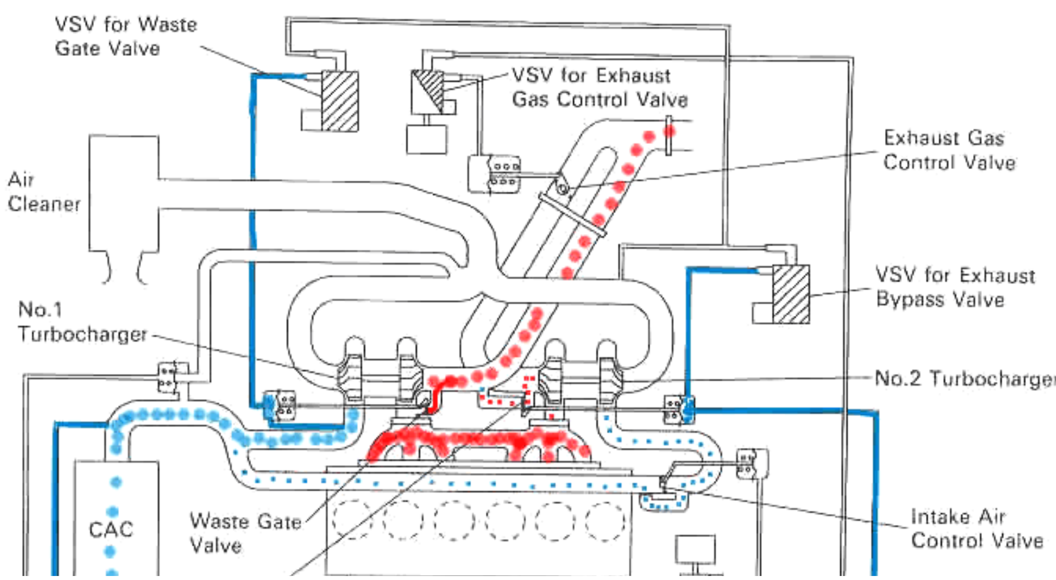
EGCV and IACV are still shut, but turbo #2 is not completely asleep.

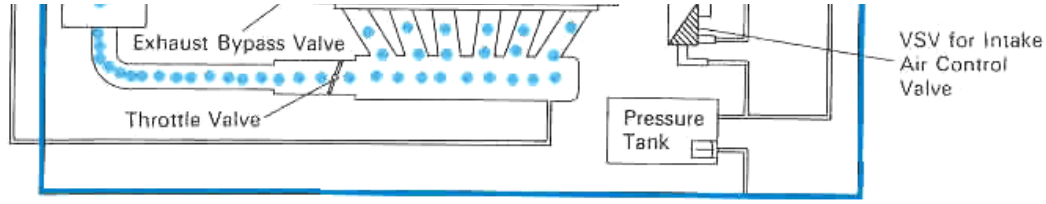
The ECU is pulsing the WSV and EBV VSVs, gradually pressurising the actuators.



As a result the EBV is now cracking open, so there is a trickle of exh gases via the exhaust bypass pipe through the turbine of #2 which is now freewheeling.

Looking closely we can see that this flow is because of the pressure differential between the cooled-down and fast-moving (ie lower-pressure) gases leaving the #1 turbine and the full output of turbine #2, most of it still has no choice but to make its way via stage exit left (the exhaust 'connector' concertina pipe and exit via turbine #1)



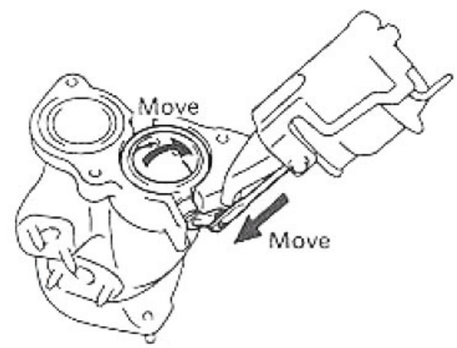


3rd Movement: Adagio --- Mid-rev operation (3800-4000rpm)

(second turbo coming on boost)

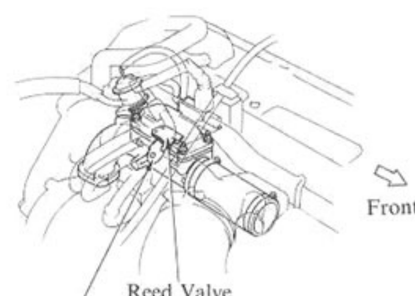
EGCV is opened by the ECU:

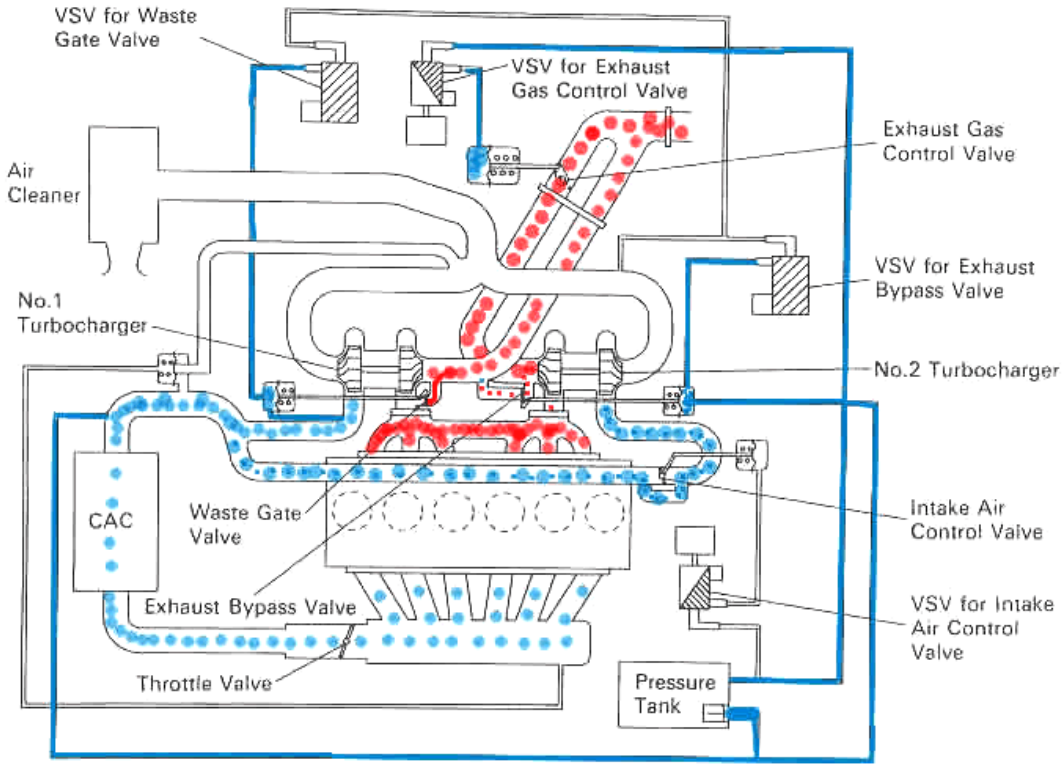
Its actuator is forced open as the EGCV VSV opens and boost pressure rushes from the pressure tank



The IACV is still shut, so any boost turbo#2 produces joins the rest of the crew via the reed valve.

It can only spin so much with it's intake being in deep vacuum (still throttled by the IACV)



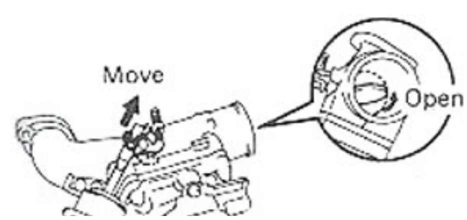


Fourth Movement: Fugal finale --- High-rev operation (4000+ rpm)

(second turbo full on boost)

The EGCV has already been opened by the ECU by now

Very soon afterwards the IACV is also opened by the ECU:
Its actuator also forced open as the IACV VSV opens and boost pressure rushes from the pressure tank

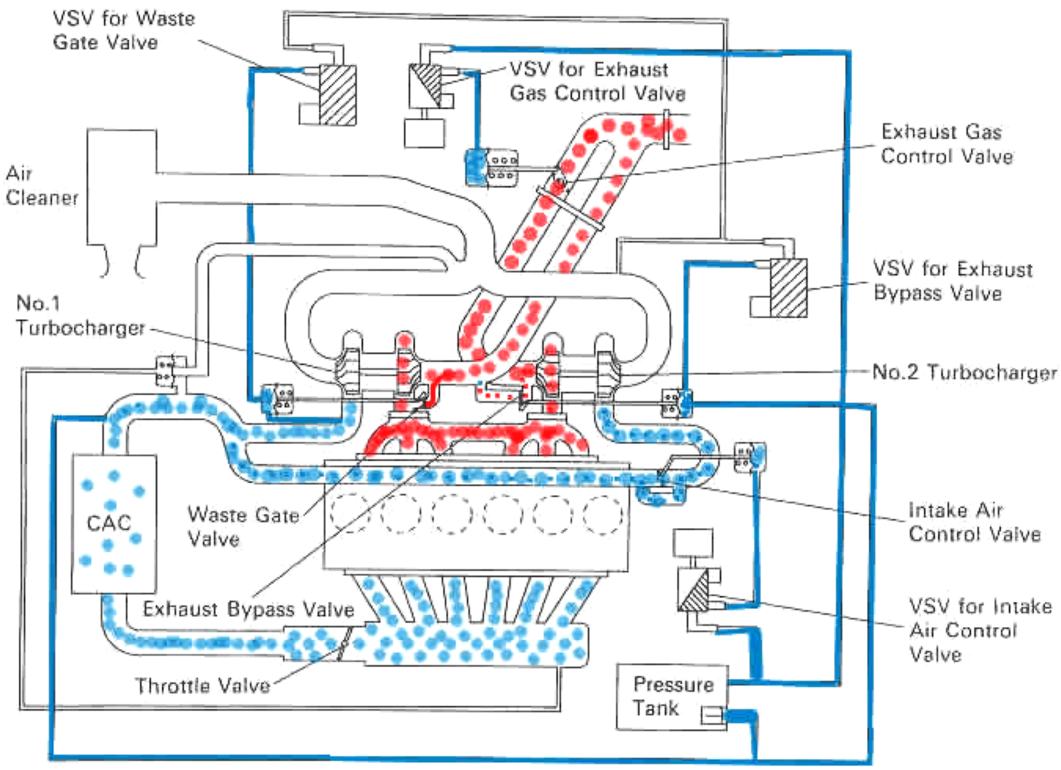


M A X B O O S

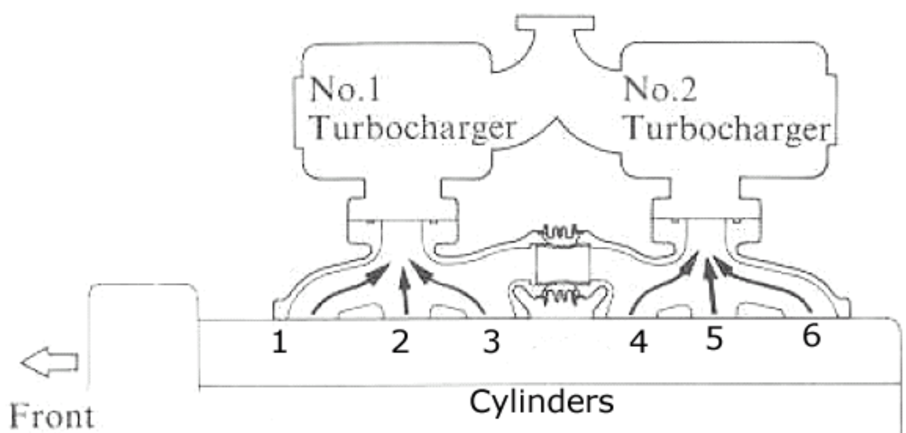
T

INDEX

Turbo #2 now produces full boost and it's airflow joins the output of #1 via the wide "Y" intake join.



At this stage the whole system is symmetrical:
Cylinders 1,2,3 push their exhaust gases straight into turbine#1 (the exhaust ports are aligned accordingly).
Cylinders 4,5,6 push their exhaust gases straight into turbine#2 (their exhaust ports are also aligned accordingly as shown below).



The flow via the 'connector' exhaust pipe is now virtually zero, since there is no pressure difference across it.

The reed valve is now also deprived of airflow, since the wide open IACV eliminates any pressure difference across it.

The EGBV is also irrelevant now, since it also is deprived of airflow (courtesy of the wide open EGCV)

The only way for the ECU to enforce boost control for the whole system now is via the WGV of turbo#1. This actuator is **always** pressurised with boost gases --- in contrast to the IACV and EGCV which are only pressurised from the pressure tank whenever their VSVs allow it.

In fact the WGV has a lot in common with the EBV:

1. their actuators are both being fed continously boost pressure from the intake (and not the pressure tank)
2. their VSVs are further downstream from their boost source. Under low load operation that boost is being bled away at the intake right after the MAF meter (since this is metered air, i.e. it has been accounted for so the ECU has already put aside fuel for it). Both of these 'relief' paths meet at the top of the engine, where low-rev boost control can be affected, but more on this later.
3. Under high load operation boost is kept inside these actuators, as the VSVs are *pulsed* closed by the ECU.

As high and low-rev boost control is down to these two valves, it makes sense that they share so many operational characteristics.

The other 'pair' of similar valves is the EGCV and IACV combo. These share the following:
1. they are both shut at their idle state (forcing turbo #2 to stay asleep)
2. they both have their actuators pressurised by the pressure tank, and not directly by the boost 'signal'.
3. they are not pulsed open by the ECU, rather forced wide-open by the full force of the pressure tank.
4. they both have their VSVs upstream of their boost source (the pressure tank)

It is important to understand the whole sequential operation, or else any attempt to modify boost control can end in tears. The frequent turbocharger failures of 'boosted' supras are testament to such poorly thought-out hacks.

Believe it or not, the above description is somewhat oversimplified, to aid clarity. The air bypass valve (stock dump valve) has been left out since all such OEM recirculating valves operate on similar grounds. Here is a more complete one with EGR, EVAP and other hose connections.

On top of all these static relationships, the rpm ranges are rough and they ***do*** vary according to the position of the throttle and also the rate of it's movement. For example the ECU orders the IACV open a bit after the EGCV has opened. If the throttle is fully open however, this rev 'gap' is deliberately shortened compared to that of mild acceleration.

Here is Mr T's way to test the VSVs

EBV EGCV IACV WGV

....on to Boosting the Beast