The objective of this meeting is to explore....

In conjunction with this theme one could ask whether the CONTROL OR ENHANCEMENT OF INSTABILITIES IS A NEW FRONTIER in FLUID MECHANICS?
In a way of introduction I shall start with what we know best namely

**SYNOPSIS**

Exploitation of instabilities generated by spanwise vorticity in 2D or quasi 2D flows

Streamwise vorticity is it secondary or primary instability

Interaction between pairs of streamwise vortices and mean shear flows as a building blocks for controlling turbulent shear flows
Traditional ways to control separation is either by removal of spanwise vorticity (SUCTION) or by addition of negative vorticity BLOWING.

IN A WAY OF INTRODUCTION
If we consider Separation, it was controlled by suction, steady blowing, and periodic excitation.
All these were based on 2D experience with slots spanning the flow and adding or removing spanwise vorticity.
When the flow is separated there is a mixing layer existing above solid surface.
It is sensitive to small disturbances and if these are amplified by externally imposed small amplitude fluctuations resulting in reattachment.
PIV shows it quantitatively
The linear stability approach to a turbulent mixing layer helped us to understand the process and it did very well predicting details of periodically forced flow and indicated what frequencies were needed for most effect at a given location. Eddies inclined downward toward the low velocity stream.
In a global sense, the instability generated eddies remove fluid from the surface lowering the pressure.

The idea is proven by PIV measurement
This concept allowed the flow to be attached and alleviated the download. This is in a way of introduction but it is not the main topic of my talk.
But here I would like to depart from the introduction
Why is it that when we do not force the (spanwise) azimuthal in this case $K_H$ eddies we note strong streamwise vortices that seem to be as significant at times as the other ones
We thought of them as seconday and in some instances they very well may be
In the early 1980s when Ari joined TAU I tried to set him on this problem and got this facility built together with heating elements for actuation along the span, but other than nice pictures little came of it.

A few years back KIT and I used a chevron trailing edge fliperon that oscillated Secondary instability.
Certain phenomena could be explained but the feeling was that this is not a secondary phenomenon.
The most significant observation is that the mixing layer spreads out as if it were 2D origination at the local TE.

But the location of the CENTER is not known and it does the opposite to what intuition would have suggested.

Traversing the flow in a horizontal direction one see a wake profile and vertical vorticity that bends to the streamwise direction LIFTING LOW SPEED FLUID IN THE CENTE.
Rolf Sondergaard, Suichuan Ou, and Richard B. Rivir 2006
\lambda = 12.7 \text{ mm}

Micro VGs with different spacing (\lambda) evolved into the same scale far downstream
The development of the spanwise distortion of $U$ with $\theta$

Normal distribution of $U$ showing distortion resulting from quasi-steady longitudinal vortices.
Streamwise vortices may interact in a destructive manner with spanwise periodic excitation. The addition of periodic excitation on a circular cylinder did not delay separation on the contrary.

It regulated the streamwise vortices and perhaps strengthened them. They simply bobbed up and down on the spanwise eddies.
Fluidic Oscillators developed in Harry Diamond Research Labs

Explain principle
Presentation aims to prove the functionality of spanwise sweeping jets for Separation based on 4 experiments

- Development of fluidic oscillators in 1950's
- Produce a jet that is sweeping like a wind shield wiper
- Most AFC methods (especially for 2D) aim to enhance spanwise vorticity
We decided to have a proper test using SLA made actuators integrated with the flap.

The material was transparent, initial access to each feedback channel was provided plugs were used to block the access.
For $\alpha=0$ and flap deflected $20^\circ$ baseline $C_L=0.7$ and it increases to 1.7 using sweeping jets at $C\mu=2\%$ and $Re=0.4M$. Tripping is most significant for the baseline.
Gap between rotors and model to measure only aerodynamic forces of downwash on using sweeping jets the results was twice as good as using periodic excitation.
The Eurica moment cam when flow around a turret was investigated. Since the turret heightscales with the BL thickness
Streamwise vortices appeared and they persevered for a long distance
It brought to the foreground the question if this is not what bypass transition is all about and how important is its role in the structure of the TBL.

It usually occurs around a roughness spot, a small necklace vortex destabilizes the BL and generates aSPOT

The Latter survives
With some pattern recognition the structure directly downstream of the perturbation looked like this
So what is it that is generated by the perturbation and what were we able to see downstream
JUST the Center Region
We were able to deduce the growth pattern from 2 Vortices to 3 to 5 etc.
And so the interaction between streamwise and spanwise vortices and the mean shear flow may be a problem of primary interest and we only recently have the tools to tackle it.
CONCLUSIONS

Exploiting instabilities rather than forcing the flow is advantageous

Simple 2D concepts may not always work

Non-linear effects may result in first order effect

Interaction between spanwise & streamwise vortices may have a paramount effect on the mean flow, but this interaction may not always be beneficial
There is a solution of the NS equations for LAMINAR FLOW and a road map for self similarity in Turbulent flows.

Self similar turbulent shear flows were most useful in helping us understand fundamental physics of a problem e.g., Mixing layers.
$S_{mt} = 0.65$ (spherical)
$S_{mt}=0.65$ (cylindrical)