



**VAKULENKO Sergey**  
research engineer

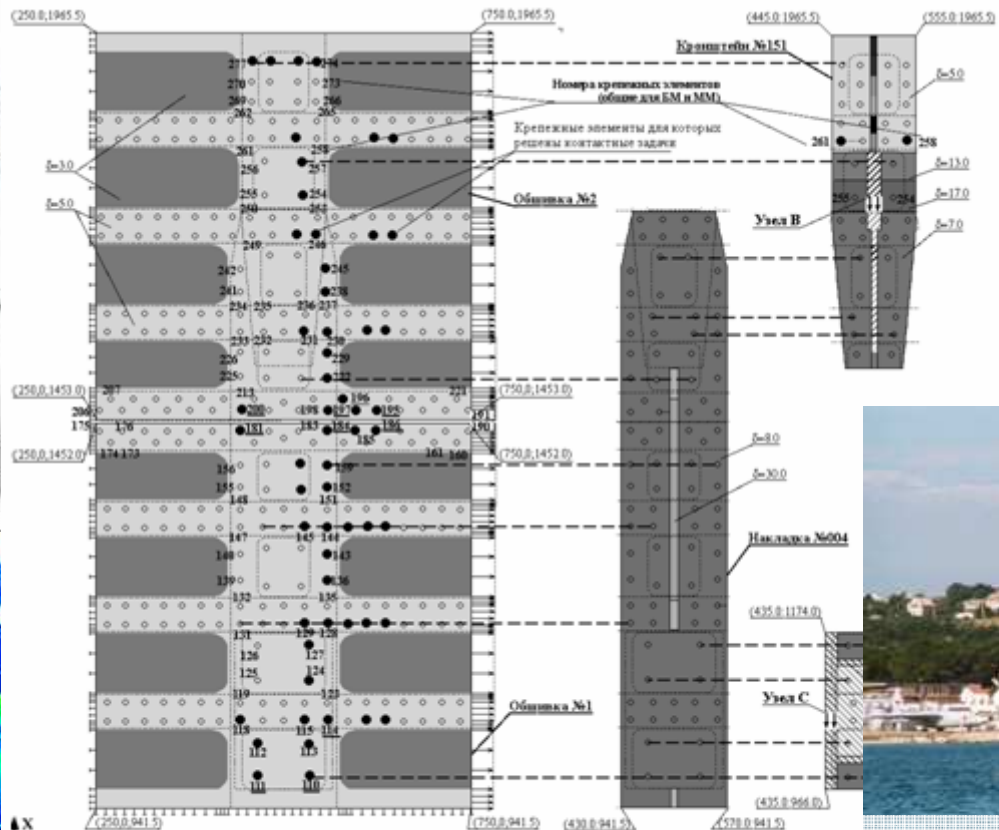
**Research Laboratory “Prochnost”**  
creating a future of strength & durability calculations

National Aerospace University  
named after N.Ye. Zhukovsky  
“Kharkov Aviation Institute”

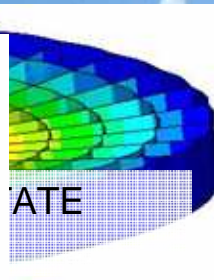


# OUR EXPERIENCE

We have accumulated more than 50 years' experience in the field of strength and durability.



Расчетные схемы и граничные условия по обшивкам № 1 и 2, накладке №004 и кронштейнам № 050 и 151 нижней панели центроплана в зоне вертокрыла, малая модель (ММ)



STATIC STRUCTURAL TESTS OF FUSELAGE



STRESS STATE AND DURABILITY CALCULATIONS OF BE-200 STRUCTURE

CALCULATION OF LENS HOLDER USED IN SPACECRAFT

LUGGAGE RACK DEFORMATION TEST

STATIC STR

STRAIN GAUGING TEST



# METHOD OF DURABILITY CALCULATION BY LOCAL STRESS-STRAIN STATE

- ✓ We have developed a high-precision method of aircraft structures durability calculation
- ✓ Energy fracture criterion used
- ✓ Permissible stresses could be calculated

Geometrical parameters



General stress-strain state



## OUR METHOD

Loading history

Advanced material data (residual deformation kinetics)

Local stress-strain state



Durability



## ADVANTAGES OF OUR METHOD

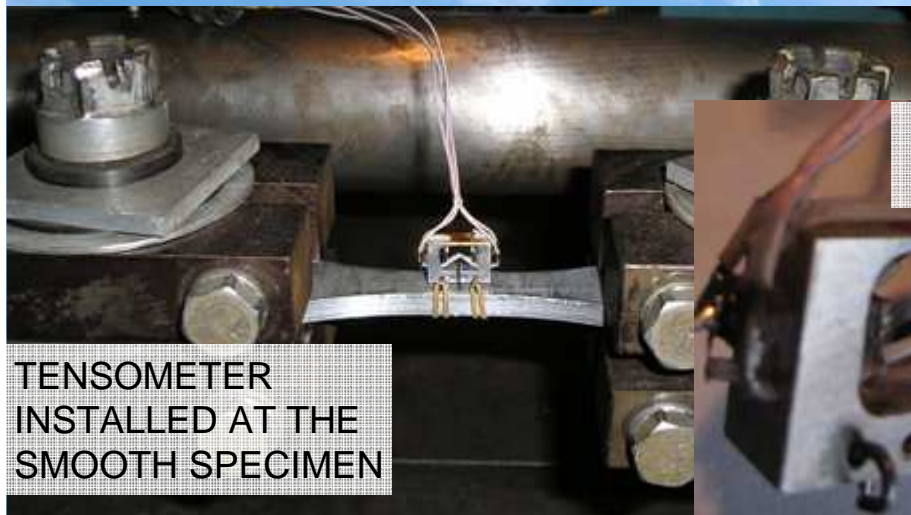
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	<b>Method of calculation by local stress-strain state (our method)</b>	<b>Method of calculation by nominal stresses (conventional)</b>
<b>Problem</b>	<b>What is required to solve the problem</b>	
Durability calculation, consideration of material changing	Smooth specimens fatigue tests (cheap and quick)	Structural elements fatigue tests (very expensive)
Consideration of complex types of loading, operational conditions, flight profiles, choice of design solution	Calculations only	Fatigue tests of structural elements with complex loading

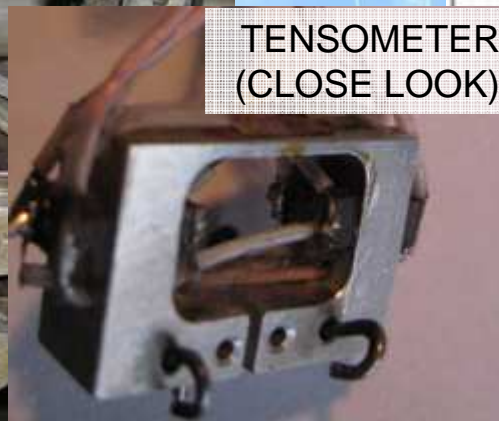
# FATIGUE AND CYCLIC STRAIN DATA TESTS

During the tests we measure the residual strain kinetic diagrams for smooth specimens

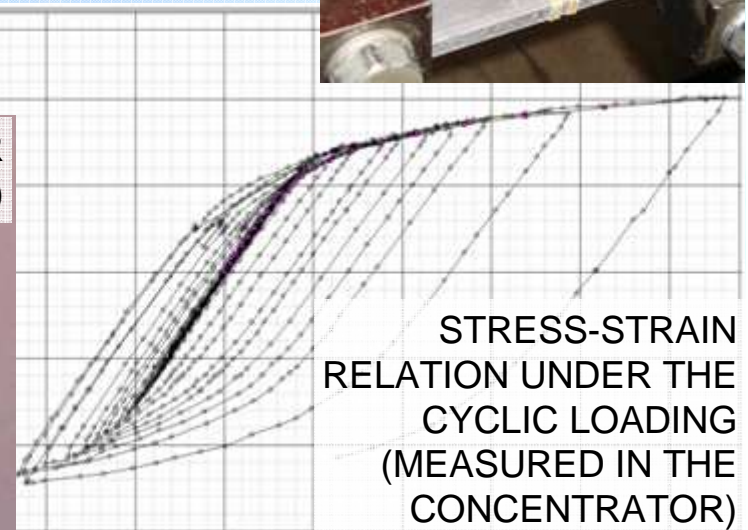
- ✓ Specifically designed hardware and software was developed, manufactured and tested
- ✓ Now we are able to measure as small residual strains as 50 nm!
- ✓ **These measurements significantly reduce the amount and costs required for fatigue tests**



TENSOMETER  
INSTALLED AT THE  
SMOOTH SPECIMEN



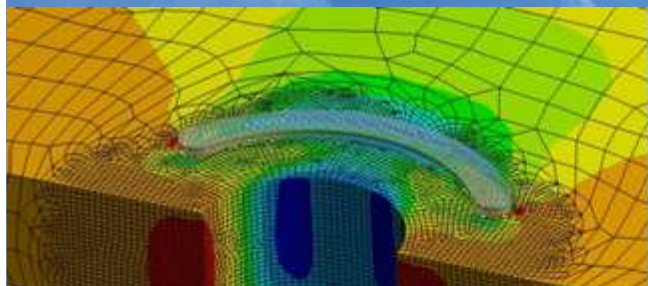
TENSOMETER  
(CLOSE LOOK)



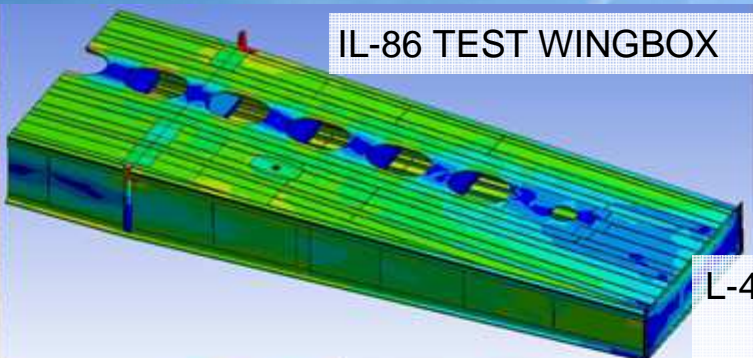


# FINITE ELEMENT ANALYSIS

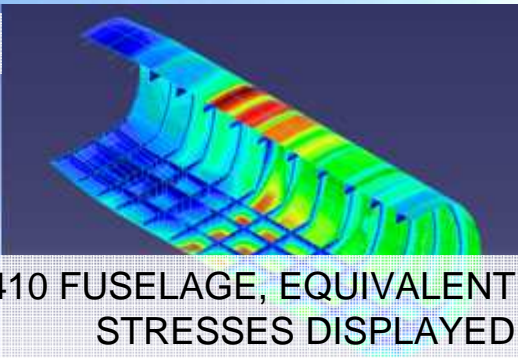
- ✓ We have successfully solved a lot of FEA problems related to the general and local stress states.
- ✓ We have developed a specific FEA software for our needs



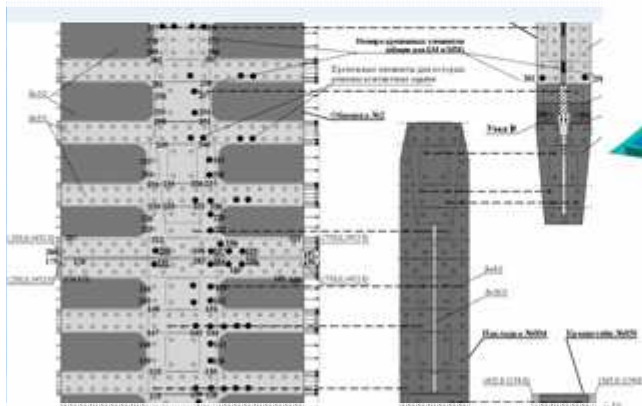
LOCAL STRESS-STRAIN STATE OF THE TENSIONED SPECIMEN WITH THE CRIMPED HOLE



IL-86 TEST WINGBOX



L-410 FUSELAGE, EQUIVALENT STRESSES DISPLAYED

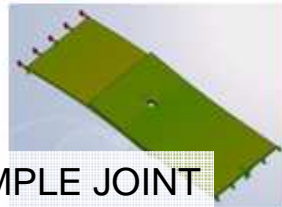


LOCAL STRESS-STRAIN STATE CALCULATIONS FOR BE-200, OUR SOFTWARE USED



AN-148 PANEL

GENERAL STRESS-STRAIN STATE OF BE-200 WINGBOX, SHEAR STRESSES DISPLAYED



SIMPLE JOINT



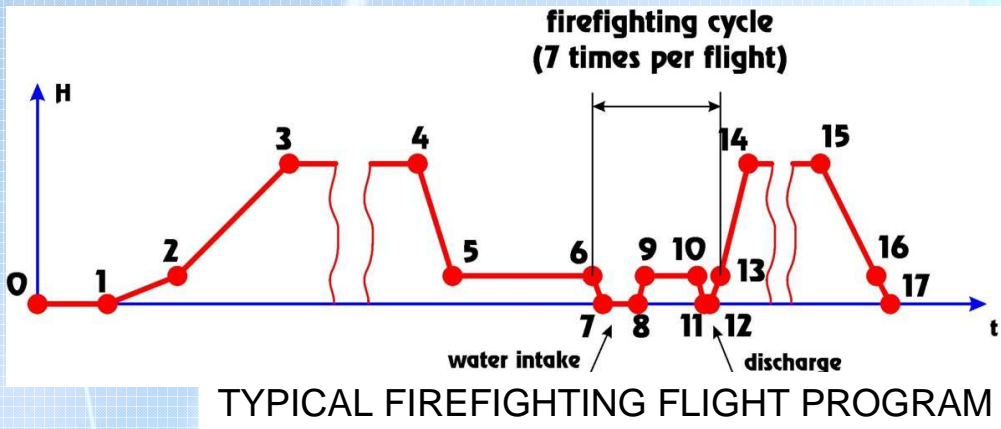
VERTICAL DISPLACEMENTS



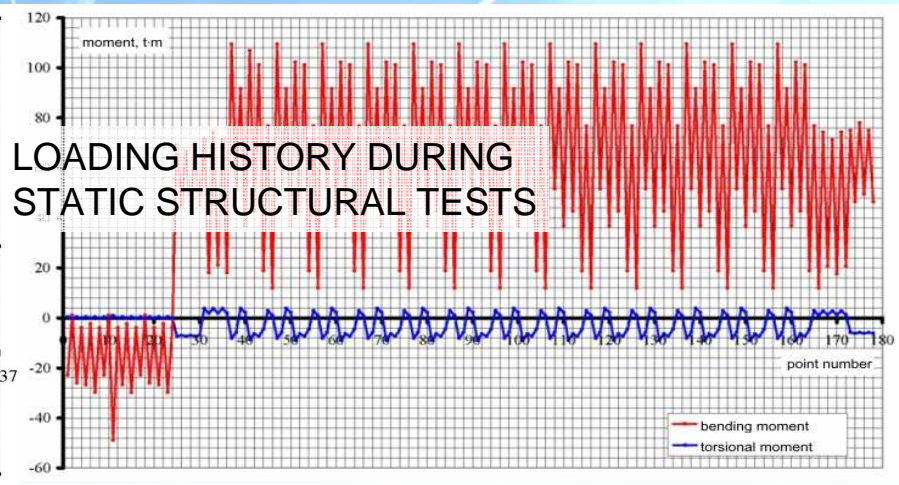
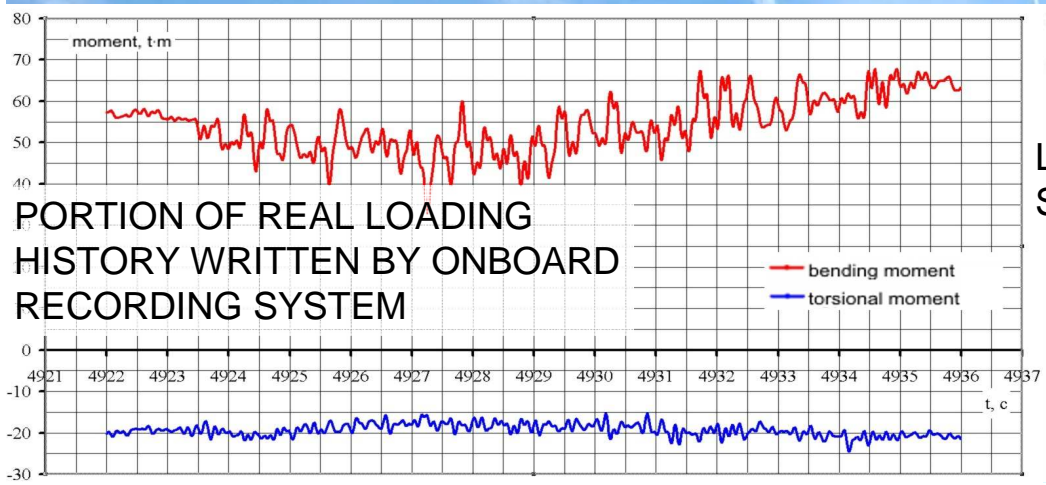
# ACHIEVEMENTS IN DURABILITY CALCULATIONS

We have provided the comprehensive durability and permissible stress calculations for our industrial partner – Beriev Aircraft Company (Taganrog, Russia), involving such facts as:

- ✓ Complex load histories
- ✓ B95 specific material data
- ✓ Specific design solutions



**We achieved the 15% accuracy of durability calculations.**





## STATIC STRUCTURAL TESTS FOR AIRCRAFT CERTIFICATION

- ✓ We are officially certified to make the tests according to AP-23 (subparts C,D) and JAR-VLA (subparts C,D).
- ✓ We have made the tests for certification of Yak-40, X-32 “Bekas”, L-410 (fuselage structure modification) etc.
- ✓ We develop the officially approved documentation in the field of static structural tests



X-32 “BEKAS”



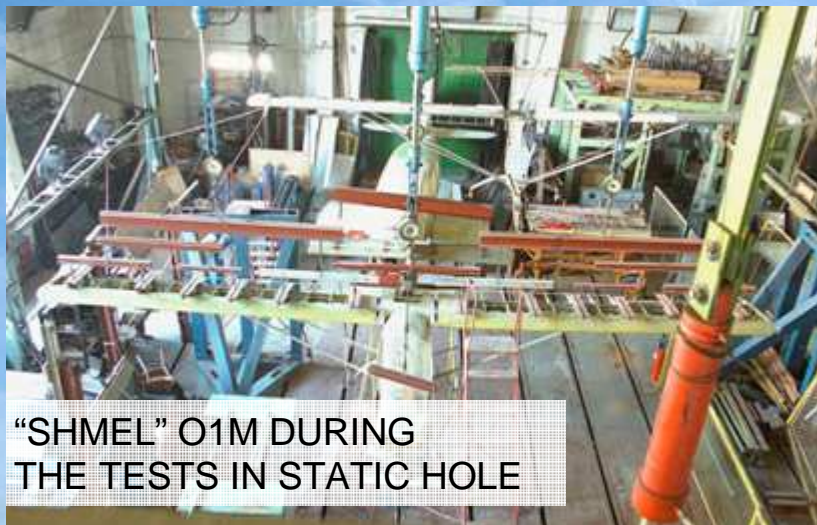
L-410UPV-E



## OUR TESTING EQUIPMENT AND CAPABILITIES

- ✓ 432 m<sup>2</sup>, 10 m high static test hole; loads up to 100 kN/m<sup>2</sup>
- ✓ Multiple hydraulic loading systems, able to create a concentrated force up to 500 kN
- ✓ Hydraulic test machines producing static and cyclic loads up to 500 kN

*... the list continues at the next slide ...*



“SHMEL” O1M DURING  
THE TESTS IN STATIC HOLE



“GRM”  
HYDRAULIC  
TEST  
MACHINE



## OUR TESTING EQUIPMENT AND CAPABILITIES

- ✓ ZD10/90 electromechanical test machines, up to 100 kN, fully automated and equipped with analog-digital converters
- ✓ UMM and UMP electromechanical fatigue test machines, cyclic loads up to 20 kN (UMM) and 50 kN (UMP)
- ✓ All fatigue machines are automated and equipped with complex electronics and software ensuring precise measurements of residual strain kinetics



“UMM” FATIGUE TEST MACHINE



“ZD10/90”  
TEST MACHINE



## WE ARE READY FOR COLLABORATION

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- ✓ Development and enhancement of methods of strength and durability calculations
- ✓ Scientific foundation and development of airborne life time counters
- ✓ Fatigue and static structural testing
- ✓ Any other proposals in the field of aircraft strength & durability



# THANK YOU FOR YOUR ATTENTION!

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named after N.Ye. Zhukovsky  
“Kharkov Aviation Institute”

Research Laboratory “Prochnost”

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